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**COMPUTER SIMULATION STUDY OF THE  
JOINT DEPLOYMENT OF THE 23RD WING  
AND 82ND AIRBORNE DIVISION FROM POPE  
AIR FORCE BASE**

**THESIS**

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COMPUTER SIMULATION STUDY OF THE JOINT DEPLOYMENT OF THE  
23RD WING AND 82ND AIRBORNE DIVISION FROM  
POPE AIR FORCE BASE

THESIS

Presented to the Faculty of the School of Logistics and  
Acquisition Management  
of the Air Force Institute of Technology  
Air University  
In Partial Fulfillment of the  
Requirements for the Degree of  
Master of Science in Logistics Management

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September 1993

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## Preface

The purpose of this study was to develop a computer simulation model that could help determine the resource requirements of a simultaneous deployment of Army and Air Force elements from Pope AFB. This model is needed to augment a feasibility study of the Pope AFB system that was recently completed by the Air Mobility Command (AMC).

While much of the expertise used in modeling the system came from transporters with the 3rd Aerial Port Squadron, planners at AMC, and documentation of lessons learned during past large-scale deployments, we also drew heavily from our own substantial experience in mobility operations. Although this study produced only a partial model, it's opened doors for further research. The completed segments show the sensitivities of the actual system and lay the foundation for development of a generalized resource sizing model.

During the long hours spent on model formulation, coding, and debugging, as well as the actual writing of this thesis, we had a great deal of help from others. First and foremost, we would like to thank our wives, Laura Prechtel and Patti Wingreen, for their patience, understanding, and support throughout this period. A word of thanks is also due to Lt Col Dave Diener and Maj Judy Ford, our thesis advisors, for the direction and assistance they provided.

Brad Prechtel and Mark S. Wingreen

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Abstract

This thesis produced a model of the Army airdrop segment of the Pope AFB deployment system. The original intent was to model the entire Pope AFB deployment system and simulate the simultaneous airland deployment of the 23rd Wing and airdrop deployment of the 82nd Airborne Division; however, time constraints and incomplete data forced a reduction in scope. The study provides an excellent foundation for further research into the use of simulation to develop a generalized deployment resource sizing model.

The airdrop segment of the system was modeled using information obtained from the researchers' personal observations of the system, the expertise of personnel who work within the system, and documentation of the problems and lessons learned during previous large-scale deployments. The parameters determined to significantly affect system performance were modeled; those that didn't affect system performance were not. The conceptual model was validated through comparison of the conceptual model and the actual system with air transportation experts assigned to Pope AFB. The coded model was then verified through 1) numerous runs in test mode where the researchers iteratively refined the coded logic and 2) sensitivity analysis that determined the model behaved as expected by experts within the Pope system.

COMPUTER SIMULATION STUDY OF THE JOINT DEPLOYMENT OF THE  
23RD WING AND 82ND AIRBORNE DIVISION FROM  
POPE AIR FORCE BASE

I. Introduction

Background

With the recent decline of the Soviet threat and the subsequent downsizing and restructuring of the United States military, rapid global force projection has become a cornerstone of U.S. National Security policy. The new National Military Strategy outlines changing world realities in which the U.S. defense establishment faces a less stable and less predictable threat at a time when defense budgets are being reduced significantly. In this environment, which stresses flexibility and efficiency of operations, military commanders will rely more and more on U.S.-based forces to rapidly respond to contingencies worldwide (CCW, 1992: 1-1).

The New Air Force Composite Wings. In response to this new National Military Strategy, the Air Force has developed two composite wings and is in the process of designing a third. The composite wings combine dissimilar aircraft, such as fighters, refuelers, and bombers, which offer different air combat capabilities, into a single wing controlled by one "boss" and capable of providing more

firepower and a broader spectrum of capabilities than a single traditional wing alone can provide. The 366th Wing, located at Mountain Home AFB, ID, was designed for air intervention and includes F-16, F-15C, and F-15E fighter aircraft, E-3A airborne warning and control aircraft, KC-135 refueler aircraft, and will add either B-52 or B-1B bombers. The 23rd Wing, located at Pope AFB, NC, contains 16 C-130 transports and 24 A-10 and OA-10 fighter aircraft, and is currently adding F-16 fighters. The 23rd Wing will provide the Army's 82nd Airborne Division (collocated with Pope AFB at Fort Bragg, NC) with tactical airlift, close air support, and battlefield air interdiction. A third composite wing, fashioned after the 23rd Wing, is projected for Moody AFB, GA and will support the Army's 24th Infantry Division based at Fort Stewart, GA. (Bird, 1992:14).

The concept behind the composite wings is, in part, to have available a logistically lightweight, self-contained fighting force that can get to the battlefield quickly and provide a variety of air power capabilities immediately upon arrival (Bird, 1992:18). The composite fighting force is more easily tailored to the requirements of a specific military operation and thus more responsive to short notice, low-intensity contingencies than a similar force drawn from a number of geographically and organizationally separate air wings (CCW, 1992: 1-2). This assertion is intuitively appealing for a number of reasons. First, since all

deploying air forces will be working for the same wing commander, "turf battles" should be minimal. A number of different wings won't be vying for support of their own parochial interests and a more concerted deployment effort should result. Coordination of deployment actions will also be vastly simplified. Finally, the logistics tail, which is the support equipment and personnel required to operate deployed forces, should be somewhat reduced since one deploying wing will tend to better coordinate support requirements than a number of dissimilar wings could.

Both the 23rd Wing and the projected Moody AFB wing are what have been termed airland operations wings (ALOWs) whose primary mission is to deploy with and support Army ground forces. The wings are designed to support a division-sized force and are capable of both stand alone and integrated air/ground operations with up to a corps-sized Army element. The concept of operations for these ALOWs is referred to as the "Integrated Operations Concept for Corps Element and Airland Operations Wing", or more simply "CCW" (CCW, 1992: iii). The CCW, which is still in a developmental stage, is discussed below.

The CCW and the 23rd Wing/82nd Airborne Division  
Affiliation. The Air Force wing/Army division team envisioned in the CCW will provide the nation with a highly mobile, yet complete, joint force capable of rapidly deploying into a hostile environment, gaining an initial

foothold, and operating effectively as a self-contained unit until augmented by more traditional service elements. The Army and Air Force units that make up the team provide pre-tailored, rapid-response force packages that will be the first forces deployed in a contingency. The missions envisioned for the CCW team include "forcible entry/force projection, air assault, base defense, and non-combatant evacuation operations in a non-permissive environment" (CCW, 1992: iii, 4-2). The affiliation between Air Force ALOWS and Army rapid response units will be maintained during both peacetime and contingency operations so the units will be familiar with each other's capabilities. The Air Force Chief of Staff, General McPeak, describes the wing/division relationship this way:

Together this team will comprise the nation's premier forcible entry capability for the future. The wing will not be chained to a division--the joint commander in a theater can break the wing loose, if absolutely necessary. But make no mistake, the idea is to form an air-ground team. The day-to-day teamwork between the wing and the division will overcome a problem that has always concerned me. These units will not be strangers meeting each other for the first time on the way to do some incredibly difficult combat task. They will work together, get to know each other, and give new meaning to the idea of joint teamwork. (Policy Letter, 1992)

The activation of the 23rd Wing (an ALOW) and establishment of the CCW concept significantly alters the long-standing relationship between the Army's Fort Bragg and the Air Force's Pope AFB. Traditionally, the overriding

mission of the Air Force at Pope AFB was to rapidly deploy the 82nd Airborne Division, which was usually among the first echelon of ground forces deployed in response to a contingency. Now, however, the Air Force has some very significant deployment requirements of its own at Pope. This change has caused concern among Army leadership that Pope AFB may currently not be able to deploy the 82nd Airborne Division in a timely manner (Betsch, 1992: 1). As a result, personnel at Forces Command (FORSCOM), Transportation Command (TRANSCOM), Air Combat Command (ACC), Air Mobility Command (AMC), and the 23rd Wing have been studying the feasibility of a large-scale, joint deployment of the forces specified in the CCW from Pope AFB.

The Pope AFB Deployment Environment. The Pope AFB deployment environment is different than that currently found at any other Air Force base. First, the main unit that processes and deploys from Pope is a rapid response Army unit as already mentioned. With the addition of the 23rd Wing's mobility requirements, the base must now simultaneously conduct two similar, but different, deployment operations. The 82nd Airborne Division, like all Army units, deploys under the guidelines of AFR 76-6, "Movement of Units On Air Force Aircraft," while the 23rd Wing, like all Air Force units deploying from home station, deploys under the guidelines of AFR 28-4, "USAF Mobility Planning." Differences between these two operations range

from types of structure to paperwork requirements, but for the purposes of this study, one of the most important points is that they are different, geographically separate operations.

Another important element that separates the Pope AFB operation from the mobility operations at other Air Force bases is the type of equipment that the 82nd Airborne Division deploys during an airdrop deployment. In this type of deployment, a number of pieces of equipment weighing in excess of 10,000 pounds each are routinely configured on airdrop platforms (basically a pallet designed to be dropped from an airborne aircraft), which are too large to be moved with a 10K forklift. This fact makes the handling requirements for this equipment unlike that found at any other Air Force base engaged in normal Air Force mobility operations. These special features, as well as other significant aspects of the Pope AFB deployment operation are discussed in greater depth in chapter 2.

Army planners' current reservations with the ability of the Pope AFB operation and infrastructure to support their needs are caused not only by the addition of the 23rd Wing's requirements, but also by experience with a number of past deployments. There have been several large-scale deployments from Pope's airfield in the past where the base's infrastructure was severely strained. Deployments to Panama and Southwest Asia, as well as mobility and



Operational Readiness Inspection (ORI) exercises, all highlighted the limitations of the Pope AFB Army deployment processing and upload area, or "Green Ramp" as it is more commonly referred to, during surge aircraft outload times (Joint, 1990:83-89). With the addition of the 23rd Wing's requirements, future large-scale deployments can be expected to cause even more problems.

#### General Issue

The concern among Army leaders about the addition of Air Force deployment requirements at Pope AFB, coupled with overcrowding problems that have occurred during past large-scale deployments from the base, has prompted both Army and Air Force planners to carefully evaluate Pope AFB's assigned assets and infrastructure to determine whether it can support a simultaneous deployment of the 23rd Wing and the 82nd Airborne Division. An ACC study indicated that a simultaneous deployment was feasible from an airlift perspective while a joint 23rd Wing/XVIII Airborne Corps study concluded that the deployment was "do-able" from an air transportation support position. The Joint Deployment Study group felt the issue would be best addressed through a series of local exercises designed to test the effectiveness of joint 23rd Wing/82nd Airborne Division deployments (Plans, 1992: 1-2).

The 23rd Wing has not yet participated in any large-scale deployment exercises with the 82nd Airborne Division, but the first is planned for early calendar year 1994 (Head, 5 October 1992). The exercise will follow the scenario of an airland deployment of the 23rd Wing and an airdrop deployment of one Deployment Ready Brigade (DRB) of the 82nd Airborne Division (Eisenberg, 2 October 1992). The magnitude of the planned exercise can be seen in the number of aircraft loads scheduled to be processed and loaded -- 133 aircraft loads, or chawks, on 14 C-5 and 119 C-141 transport aircraft in a two-day time period. The deploying units, along with total equipment weight and the number of deploying personnel are summarized in Table 1 below.

TABLE 1

EQUIPMENT AND PERSONNEL TO DEPLOY  
UNDER THE SIMULATED SCENARIO

<u>Unit</u>	<u>Cargo (Short Tons)</u>		<u>Passengers</u>	<u>Paratroopers</u>
	<u>Airland</u>	<u>Airdrop</u>		
23 Wg	572.4	0	748	0
82 ABN Div	1358.5	1067.2	531	2244
JSOC	92	0	104	0

Note: 1 Short Ton = 2000 lbs.

The Transportation Plans and Programs department at AMC and the Air Land Sea Applications Center have been deeply involved in a number of studies to determine deployment requirements, constraints, and identify possible problem areas and have determined that a detailed computer model capable of simulating the simultaneous deployment of the 23rd Wing and the 82nd Airborne Division would significantly aid in problem identification. Most of the required input data was collected through a number of time studies by personnel assigned to the 3rd Aerial Port Squadron (3 APS) at Pope AFB. Personnel at 3 APS also conducted a preliminary, hand-calculated simulation of the planned deployment; however, AMC determined they currently lack the "in-house" resources to construct a computer model with the required level of detail (Head, 5 October 1992).

#### Specific Problem

This study models the Pope AFB deployment system and simulates alternative deployment scenarios to determine feasibility, identify potential deployment problem areas, and evaluate possible solutions. In particular, the study seeks to answer two questions. First, what are the requirements in terms of ramp space, facilities, equipment, and personnel to support a simultaneous deployment of Army and Air Force units from Pope AFB? Second, are enough of

those resources required to successfully support such a deployment currently available at Pope AFB?

### Research Objectives

To be successful, this research must satisfy the following objectives:

- 1) Identify the significant causal, background, and response variables within the Pope AFB deployment processing and loading operation and determine how they interact.
- 2) Identify the constraints inherent to the 23rd Wing, the 82nd Airborne Division, and the Pope AFB environment.
- 3) Determine whether an existing model can be modified and used to study the deployment problem from a "micro" or base level.
- 4) In the absence of a suitable existing model, construct a new computer model, incorporating the information from 1 and 2 above, that accurately represents the Pope AFB deployment operation.
- 5) Identify potential deployment problem areas by simulating the simultaneous airland deployment of the 23rd Wing and the airdrop deployment of one DRB from the 82nd Airborne Division.
- 6) Determine possible solutions through "what if" simulation experiments.

### Scope/Limitations

The scope of this research study is restricted to joint deployment operations at Pope AFB involving the 23rd Wing and the 82nd Airborne Division. The study does not consider any unit actions, such as cargo preparation, taken prior to cargo or passenger delivery to the deployment processing area nor does it consider enroute operations or beddown and employment at deployed locations. It also does not consider any operations not related to the deployment, such as arriving channel, or regularly scheduled, airlift missions.

Since simulation is not an optimization method, the model will not provide the optimal mix of personnel, equipment, and holding space. The model can only be used to evaluate alternatives from which to choose and to determine resource/policy sensitivities by running different combinations of constraint variables.

### Overview

The second chapter of this thesis examines the literature currently available on Air Force and airlift doctrine, general deployment operations, and deployment operations specific to Pope AFB. The purpose is to provide an understanding of the Pope AFB deployment system and some of the limitations of that system. The review includes numerous interviews and unpublished sources such as past Pope AFB ORI reports, briefings on the Pope deployment infrastructure, and the "Joint Committee Report on Operation

DESERT SHIELD," the international response to the Iraqi invasion of Kuwait. This chapter also reviews the literature on past simulation studies and general simulation modeling techniques.

The third chapter discusses model development in depth. The chapter begins with a detailed explanation of the assumptions that were made in modeling the Pope AFB deployment system. Next, the parameters and variables from the actual system that are included in the model are listed and defined and the methods for data collection and input to the model are explained. At the same time, potential users of the model are instructed how to construct the trace files which input data to the model and how to run the model file.

The fourth chapter focuses on validation and verification efforts. Verification for the airdrop model segment was completed, whereas validation is incomplete. The chapter closes by identifying the limitations of the joint deployment model.

The fifth chapter presents recommendations for future research. The most pressing of these is the need for a comprehensive time study of the various increment processing times. Suggestions for completing the model and then making it more "user friendly" and generalizing it for use in other deployment scenarios are also provided.

Additional supporting material is included in a number of appendices at the end of the text. A few of these

appendices warrant mention here. Appendices A and B provide a glossary of technical terms and a glossary of acronyms respectively. Also, Appendix C provides a copy of the communicative model of the Pope AFB deployment system and Appendix D provides the computerized simulation model.

## II. Literature Review

### Introduction

This literature review documents information used in developing a computer simulation model for analyzing joint 23rd Air Wing and 82nd Airborne Division deployments from Pope AFB, NC. The review focuses on the Air Force, airlift, and deployment doctrine that impacts on the Pope AFB deployment operation, essential elements of the Pope AFB deployment environment, past simulation studies dealing with similar issues, and some general modeling techniques. This search is necessary to obtain enough information to build the required system detail into the simulation model and ensure it is a valid representation of the actual Pope AFB deployment system, while avoiding any duplication of past research.

### Air Force, Airlift, and Deployment Doctrine

Airlift has become a critical component of the country's military forces in recent years. As early as the Vietnam conflict, during which numerous elements of the modern airlift system were created and refined, airlift was emerging as an extremely important element of force mobility. By 1980, deployment thinking had become manifest in the concept of the mobility triad of airlift, sealift, and prepositioning in which airlift was recognized as the key element (Miller, 1988). With the recent drawdown of



U.S. forces stationed in Europe and other overseas Areas of Responsibility (AORs), the airlift mission of the U.S. Air Force has become even more important, as evidenced by this statement from current Air Force Doctrine:

Airlift provides global reach for military forces, a capability of particular importance given the worldwide commitments and interests of the United States. Without airlift, the United States would be hard-pressed to respond to far-flung crisis situations. Viewed in this light, effective airlift becomes the backbone of deterrence, at least at the nonnuclear level. (AFM 1-1, 1992:187)

In addition to becoming more important to the nation's mobility posture, the basic nature of airlift operations has begun to change. The most significant change is that the concept of projecting force in three phases is no longer the method most likely favored by modern airlift doctrine (Miller, 1988). These three phases include moving forces first from either a main operating base in the continental United States (CONUS) or an established U.S. military installation overseas to a second main operating base in the theater of operations; then from the second main operating base to a forward operating base; and finally from the forward operating base to the final destination. This three-phase process is known as strategic deployment. Current doctrine recognizes that forces can get to a conflict more quickly if they are delivered directly to the final destination (Miller, 1988). Thus, we now have two established methods of delivering forces to a theater of

operations: strategic deployment and what is now termed strategic employment. The published aerospace doctrine states that

Strategic employment is used to insert combat forces directly into a theater and a hostile situation, as in Operation Urgent Fury. Such employment requires support from suppression forces as well as control of the aerospace environment. Strategic deployment or redeployment, in contrast, requires no suppression support. (AFM 1-1, 1992:188)

This new deployment thinking, combined with reduced budgets, downsizing, and the current emphasis on jointness, has contributed to the formation of the Air Force's composite airland operations wings (ALOWs) and adoption of the CCW concept. This is evidenced in the mission of the combined Air Force ALOW/Army division team -- to conduct forcible entry, air assault, base defense, and non-combatant evacuation operations in a hostile environment (CCW, 1992:iii, 1-2, 4-2). All of these operations entail strategic employment of forces. To make these complex joint employment operations work, the Army and Air Force units must train together extensively in peace time (Policy Letter, 1992). Since effective strategic employment of forces requires deployment of the right forces at the right time, the initial mobilization and deployment processing actions required in a strategic employment operation are one of the areas in which extensive training between certain Air Force and Army units is a must.

The Army and Air Force mobilize and deploy using different processes which are specified in the regulations governing each service's movement. The Air Force deploys under the guidance of AFR 28-4, "USAF Mobility Planning," while the Army deploys under the joint regulation AFR 76-6/Army Field Manual 55-12, "Movement of Units in Air Force Aircraft." Each regulation has different guidelines for the preparation and loading of unit cargo and the handling of passengers. Air Force unit moves require much more documentation of cargo and passengers than do Army unit moves. AFR 28-4 also goes into much more detail about the flow of information and control of mobility operations than does AFR 76-6.

Air Force Unit Moves. Air Force mobility operations are controlled by the Mobility Control Center (MCC), which is headed by the Installation Mobility Officer (IMO) and composed of representatives from each of the major functional areas. The MCC coordinates the actions of the deploying units and the Transportation Control Unit (TCU) to ensure unit equipment and personnel are mobilized and deployed in a timely manner (AFR 28-4, 1987:MOP 1). Figure 1 shows the functional structure of a typical Air Force mobility operation. The TCU controls all transportation functions including the Sub-Motor Pool (SMP), the Air Cargo Terminal (ACT), and the Air Passenger Terminal (APT) (AFR 28-4, 1987:MOP 3). The SMP is responsible for moving

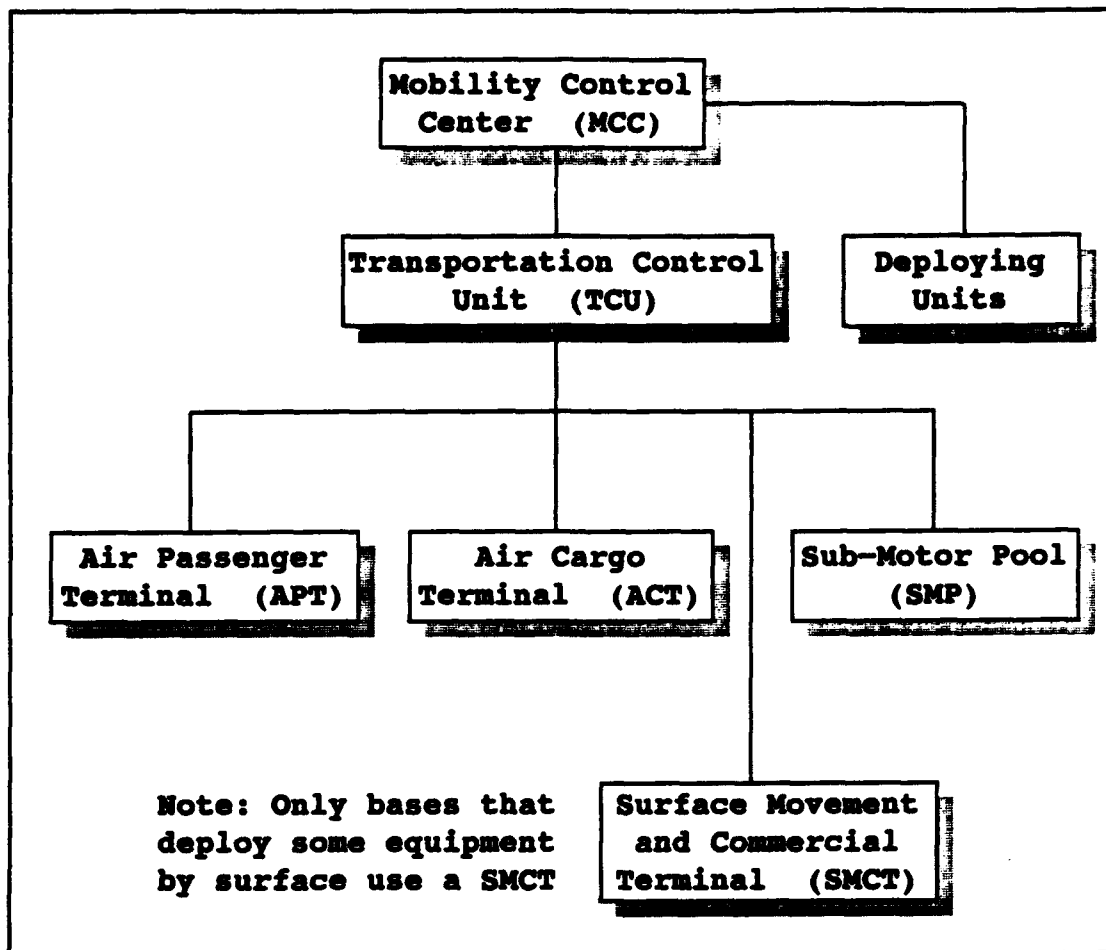


Figure 1. Functional Structure of an Air Force Mobility Operation (AFR 28-4, 1987: MOP 1, MOPS 3-6, MOP 26)

all unit cargo and passengers from the respective units to the appropriate mobility work centers and providing general vehicle support to the mobility work centers as required (AFR 28-4, 1987:MOP 6). The ACT is responsible for processing and loading unit cargo. Processing a unit's cargo involves first inspecting the cargo jointly with a unit representative and then marshaling the cargo in chalk order, which is the order in which it will be loaded aboard

the aircraft (AFR 28-4, 1987:MOP 5). Finally, the APT is responsible for processing, briefing deployment specifics to, and loading unit personnel aboard departing aircraft (AFR 28-4, 1987:MOP 4). The Manpower Processing Unit is usually co-located with the APT and assists in passenger processing by ensuring personnel are properly equipped, trained, and otherwise prepared (e.g. shots, passports, family and financial obligations met, etc.) to deploy (AFR 28-4, 1987:MOP 9).

Army and Other Non-Air Force Unit Moves. In contrast to the typical Air Force operation, Army mobility operations are controlled by the Departure Airfield Control Group (DACG). The DACG, which is roughly equivalent to the MCC and is staffed by both Army and Air Force personnel, is responsible for coordinating and controlling Army Deployments (AFR 76-6, 1989:2-2). Figure 2 shows the functional structure of a typical DACG operation. The DACG acts as the liaison between the deploying units and the Airlift Control Element (ALCE). The ALCE maintains operational control over airlift assets and personnel when the deployment operation is from a base with no organic airlift command and control element. Operational control of deploying unit equipment and/or personnel transfers to the DACG as the equipment and personnel are delivered from the units to the Alert Holding Area. In addition to accepting cargo and personnel from the deploying units, the Alert

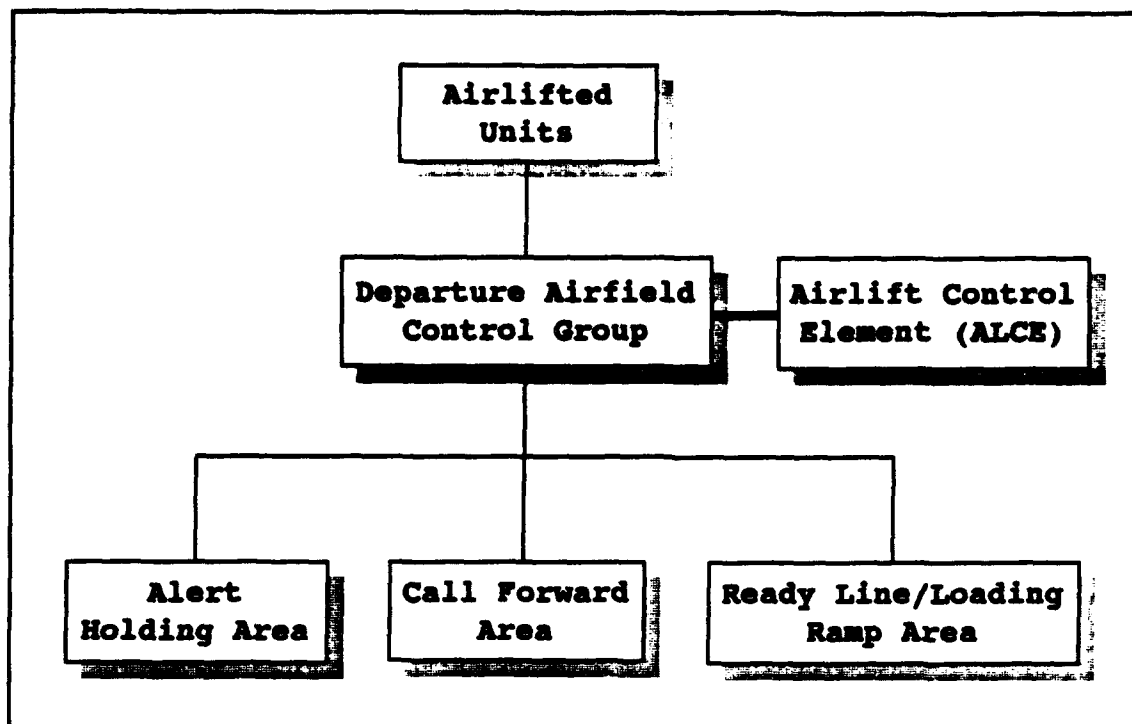


Figure 2. Functional Structure of a Departure Airfield Control Group (DACG) (AFR 76-6, 1989: 2-4)

Holding Area conducts a pre-inspection of the cargo and/or personnel and corrects any discrepancies found. The Call Forward Area conducts the Joint Inspection (JI) of cargo in which both DACG and ALCE members certify the air worthiness of the cargo. Any discrepancies noted are corrected by DACG personnel. Also, the Call Forward Area briefs deploying passengers and produces final cargo and passenger manifests. As cargo and passengers are moved to the Ready Line, operational control chops to the ALCE or other airlift control agency. In the Ready Line/Loading Ramp Area, DACG personnel load aircraft as directed by ALCE personnel (AFR 76-6, 1989:2-2 to 2-7).

### The Pope AFB Deployment Environment

As previously mentioned, the Pope Air Force Base deployment environment differs from that found at almost any other Air Force base. The following discussion briefly describes some of the main features of that environment, including operations, layout and facilities, and available resources. Many of the more significant aspects of the environment are highlighted, while some of the problem areas found and improvement recommendations made by various past studies are noted. Note that since the focus of this study is on a deployment scenario in which the Army deploys much of the 82nd Airborne Division airdrop as opposed to airland, discussion of the DACG operation is concentrated on airdrop configured loads. Since this discussion contains a number of specialized terms, readers unfamiliar with both strategic and mobile aerial port procedures should review the Glossary of Technical Terms at Appendix A before proceeding. A review of the communicative/conceptual model of the Pope AFB deployment system located in Appendix C may also facilitate a better understanding of the discussion that follows.

Deployment Operations. One of the most distinguishing characteristics of the Pope AFB deployment environment is that both an Air Force home station mobility machine and a DACG operation are used simultaneously. Due to the large amount of cargo and personnel that will move during future joint Army/Air Force deployments from Pope AFB, the current

system of MCC control for deploying Air Force units and DACG control for deploying Army units will be maintained (Williams, 16 December 1992). These two operations are organizationally independent of, and geographically separate from, each other. All Army cargo is inspected and marshaled at the DACG facility adjacent to Green Ramp and all Air Force cargo is inspected and marshaled at the Air Force Marshaling Yard on Silver Ramp and then loaded aboard aircraft on Blue Ramp. The location of these ramps can be seen in the layout of Pope AFB at Figure 3. Although this system requires duplication in many deployment functions, including command and control, the dual operation is necessary to avoid the bottlenecks that would result if all deploying Air Force and Army cargo were inspected and marshaled in one area. The duplication of inspection and loading operations, in particular, places a much greater load on aerial port equipment and manpower resources than would a consolidated operation.

The Air Force mobility operation works the same as mobility machines found on every other Air Force base. Cargo arrives at the ACT and is inchecked, joint inspected, marshaled in chalk order, and loaded aboard the appropriate aircraft as those aircraft arrive. Since all Air Force cargo is configured for airland missions, there are no requirements for specialized equipment or cargo handling procedures (other than explosive cargo). Rolling stock,



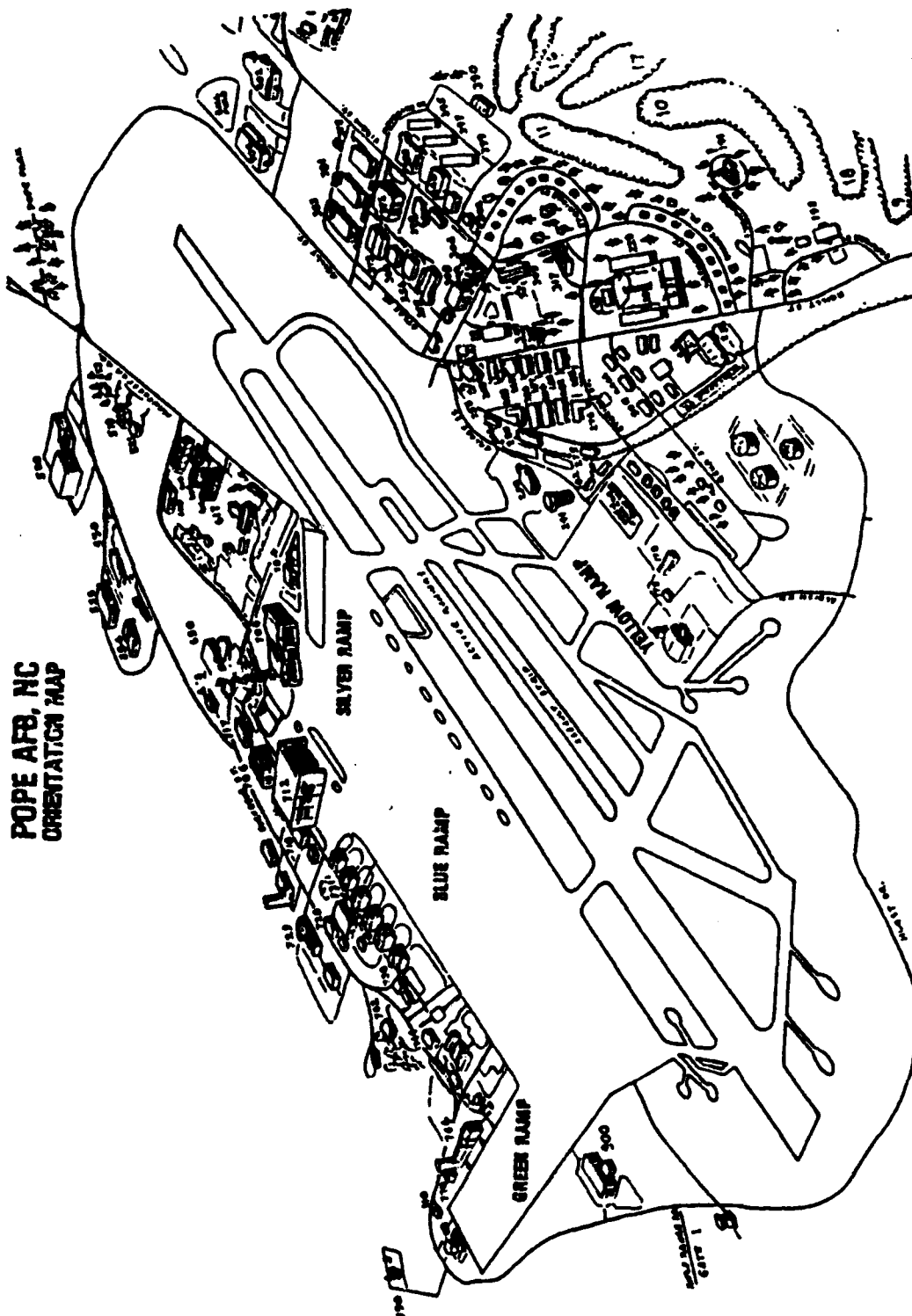


Figure 3. Layout of Pope Air Force Base

which is wheeled equipment, is either driven or, if not self-propelled, moved using a prime mover (bobtail, 1/2 Ton truck with pintle hook, tug etc.) about the marshaling yard and to the aircraft for loading. All palletized cargo weighs less than 10,000 pounds so it can easily be moved using standard 10K forklifts and stored on the ground using three-point dunnage (three 4x4s placed one at each end of the pallet and one in the middle).

In stark contrast, the Army DACG is an entirely different operation. Airland configured cargo is treated very nearly the same way airland cargo is in the Air Force mobility; however, many of the increments the 82nd Airborne Division delivers to the Call Forward Area are configured for airdrop as opposed to airland missions. The airdrop platforms used for these increment configurations cannot be stored on the ground because of their length, which is usually over 2.5 pallet positions, and/or their weight, which is usually over 10,000 pounds. The reason for this is that due to the airdrop increments length and/or weight they cannot be picked up and transported with a 10K forklift and/or loaded onto a K-Loader as can regular palletized cargo increments that are configured on standard 463L pallets. Instead, they must be downloaded from the flatbed trucks which deliver them to the scales area and loaded directly onto K-Loaders with a stationary 55-ton crane. The platforms then must be stored on either K-Loaders, highline

docks, or rollerized flatbed trailers until loaded aboard an aircraft. As a result the Army's airdrop increments are much more equipment intensive than are cargo increments configured for airland airlift missions.

Layout, Facilities, and Ramp/Marshaling Space. As previously stated, during a joint deployment at Pope AFB, the Air Force mobility machine will operate on Silver and Blue Ramps and the Army DACG operation will be conducted on Green Ramp. This section provides a brief description of the ramp space, facilities, and stationary equipment available at each location. This discussion of the Pope AFB infrastructure concludes with a look at some of the potential problem areas noted during past studies and some suggestions for future improvements.

The 23rd Wing Mobility Machine. The physical layout of the Air Force mobility machine is as shown in Figure 4. Cargo is inchecked, inspected, and marshaled on Silver Ramp and then transported to Blue Ramp for loading. The size of the marshaling yard can be varied to provide from 200 to 300 pallet positions of marshaling space (Loveland, 9 June 1993). Since no airdrop configured loads are handled at the Air Force mobility operation, there is no specialized material handling equipment located there. Passengers meanwhile are processed, briefed, and held at the APT, which is located at the Air Force Mobility Processing Center. This facility, which also houses the MCC and TCU,

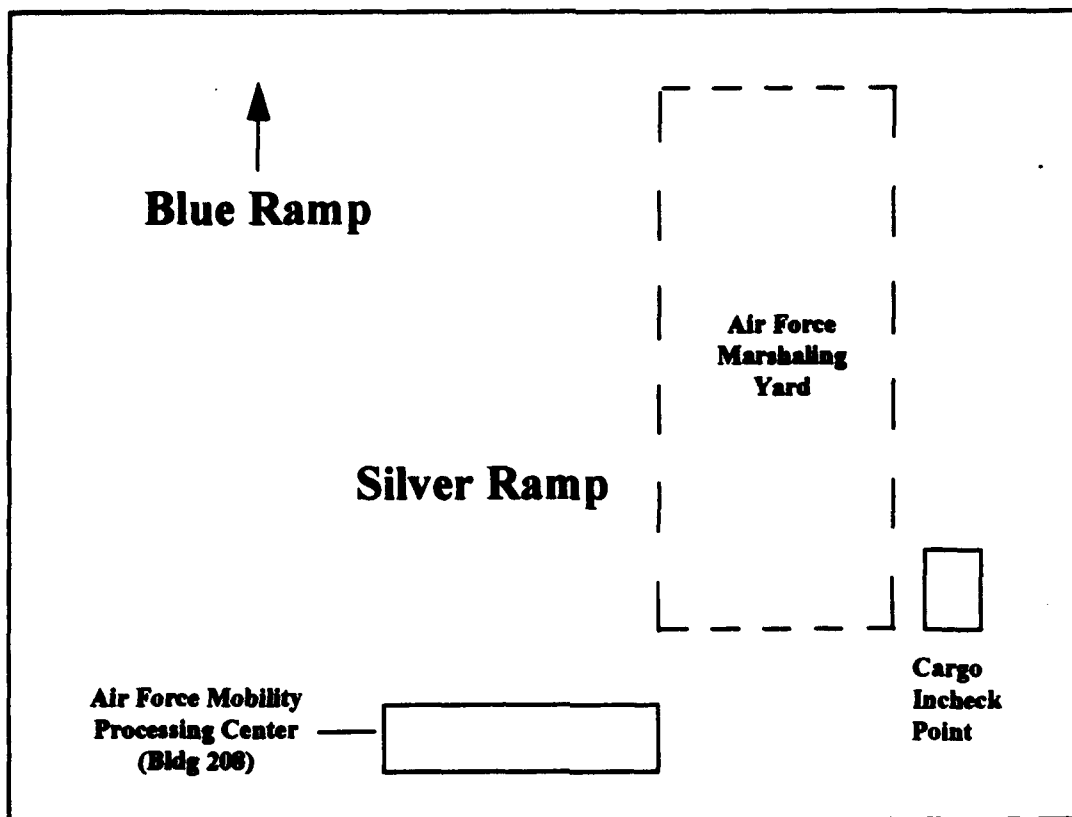


Figure 4. Layout of the 23rd Wing Mobility Machine

can accommodate approximately 200 passengers at one time (Loveland, 9 June 1993). Blue and Silver Ramps together provide parking space for up to 8 C-141s. With the 23rd Wing's aircraft flushed, capacity increases to 25 C-141 parking spots (Comstock, 1992).

The DACG Operation. The area in which the DACG operation is conducted is as shown in Figure 5. Arriving cargo is staged at the Alert Holding Area. Airdrop cargo is then weighed on the coal yard scale next to the crane and either staged on K-loaders in the call forward area or on one of the highline docks until aircraft load time. Storage

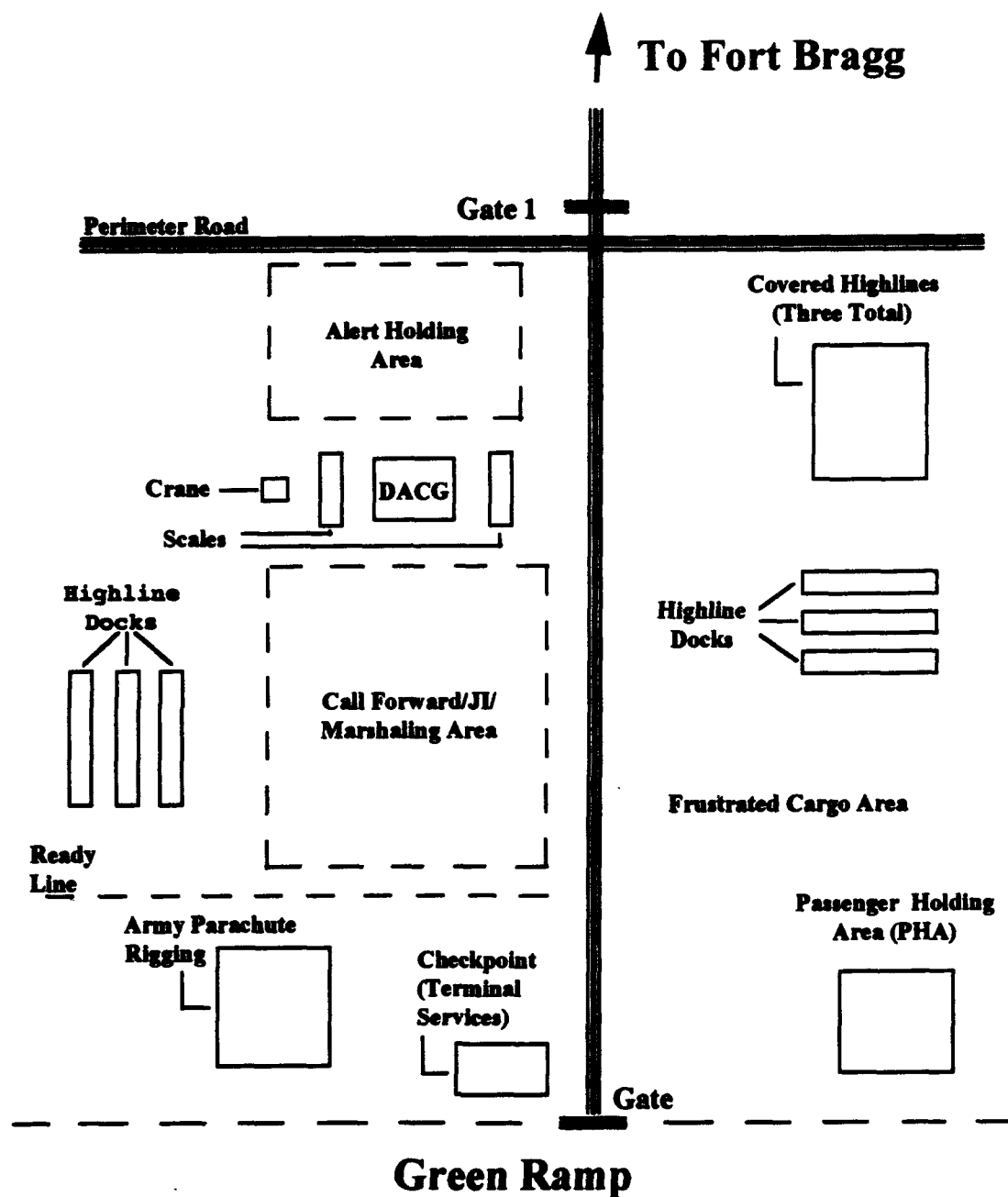


Figure 5. Layout of the DACG Operation

on K-loaders is not desirable since these pieces of equipment are needed to load aircraft. Airland cargo is

weighed at either scale and is then staged in the Call Forward Area (Rogers, 20 March 1993). The DACG Alert Holding Area can hold approximately 15 C-141 equivalent loads (about 165 463L pallets) at a time while the Call Forward Area can hold roughly 26 C-141 equivalent loads (or 310 463L pallets) (Joint, 1990:85-87). The six uncovered highline docks in the DACG area can store 40 eight-foot platforms, which is approximately four C-141 loads. Additionally, there are three covered highline docks available that hold another 20 eight-foot platforms, or roughly two C-141 loads (Joint, 1990:87; Phillips, 19 March 1993). Covered highlines are preferred to uncovered highlines because an airdrop platform stored on an uncovered highline will get wet if it rains. The extraction chutes, which are small parachutes rigged to extract the platform from the aircraft during flight, must remain dry in order to function properly. There are also 30 rollerized flatbed trailers available for use should they be needed (Williams, 16 December 1992). The Passenger Holding Area located at the bottom right corner of Figure 5 accommodates approximately 400 passengers for short periods of time. This number varies up or down by about 50-75 passengers depending on whether they are paratroopers or regular passengers. Paratroopers require more space for their equipment and thus fewer can be processed through the PHA at one time (Joint, 1990:88). Green Ramp provides a total of

14 C-141 and 4 C-5 parking spaces. Alternatively, if only C-141s are on the ramp, then there is room for 22 C-141s at any one time . There are also three parking spots for either C-141s or C-5s that are used by both deployment operations (Comstock, 1 June 1992).

Personnel. Although adequate numbers of personnel with the appropriate specialty skills are an important requirement in any operation, people can be moved temporarily from other bases to fill shortfalls relatively easily. As a result, only personnel with a few critical skills were considered in the modeling effort. Briefly then, these skills are qualified joint airdrop inspectors, qualified joint inspectors ; MHE operators who are qualified on 25K-, 40K-, TAC-loaders, and 10K forklifts; and load team chiefs (Phillips, 19 March 1993).

Material Handling Equipment. The availability of an adequate amount of Material Handling Equipment (MHE) is a critical requirement in any deployment operation. Without it, a deployment will not happen. Adding to the MHE availability problem is the fact that the most critical types of MHE, 25K-, 40K-, and TAC Loaders, are extremely maintenance-intensive. The amount of each type of MHE authorized and actually assigned to Pope AFB as of 22 October 1992 is listed in Table 2 (Support, 1992). According to air transportation personnel assigned to 3 APS, this amount of MHE is typical, although some of the TAC-

TABLE 2

463L MATERIAL HANDLING EQUIPMENT (MHE) STATUS  
AT THE 3RD AERIAL PORT SQUADRON (Support, 1992)

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<u>Type</u>	<u>Authorized</u>	<u>Assigned</u>
40K Loader	8	6
25K Loader	15	11
TAC Loader	12	12
Cochran Loader	6	4
10K AT Forklift	21	21
13K AT Forklift	4	4
10K STD Forklift	15	14
Stair Case TRK	4	4
Latrine Svc TRK (LST)	2	3

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Loaders and all-terrain (AT) forklifts may be lost due to the squadron's redesignation from a mobile aerial port squadron (MAPS) to an APS (Phillips, 19 March 1993).

Problems Identified/Recommendations Made. In the past there have been several large-scale contingency operations involving the 82nd Airborne, such as Operations JUST CAUSE and DESERT SHIELD, that have shown significant limitations with the deployment infrastructure at Pope AFB. These limitations run the gamut from ramp space to facilities and equipment. This section discusses those problems identified by the Joint Committee that studied the XVIII Airborne Corps DESERT SHIELD deployment.

The Joint Committee identified a number of resources that proved to be inadequate and made a number of



recommendations to overcome these limitations. First, the weighing and inspection of cargo at the DACG was identified as a bottleneck. This is because the DACG only has two scales at its facility. These scales are used to weigh heavy airdrop platforms and vehicles so that the center of balance can be determined. These scales limit the airland configured cargo throughput capacity of the DACG to 60 C-141 equivalent loads a day (Joint, 1990:86). Another area of concern is passenger processing, holding, and loading. Deploying Air Force personnel are processed, held, and loaded from the Mobility Passenger Terminal adjacent to Silver Ramp, while deploying Army personnel use the Passenger Holding Area adjacent to Green Ramp. The two facilities are fully utilized during mobility operations, so consolidation of operations is not feasible (Loveland, 19 June 1993). In fact, the Operation DESERT SHIELD Joint Committee recommended the Passenger Holding Area be expanded beyond its current capacity of 400 personnel. The limitation imposed by the lack of passenger processing space is evident in the fact that a requirement to load two wide-body commercial passenger aircraft within two hours of each other would easily congest the system during a deployment exercise or rapid insertion contingency operation (Joint, 1990:33). The Joint Committee also recommended enlarging the DACG cargo marshaling area to accommodate 30 C-141 equivalent loads and increasing the number of highlines so

that more palletized loads and airdrop platforms can be staged for loading (Joint, 1990:88). One last limitation covered in the Joint Committee Report is the lack of an adequate hazardous and explosive cargo storage area at Pope AFB. There is no permanent storage area near the DACG for hazardous and explosive cargo. During normal operations this type of cargo can only be stored in the marshaling area for up to four hours (Joint, 1990:88).

The various elements and parameters just discussed must be incorporated in the joint deployment computer simulation model. Through experimentation with this model, decision makers may well be able to more accurately determine the asset levels required by future simultaneous deployments from Pope AFB. The remainder of this literature review explores information that was helpful in ensuring the deployment model constructed is, indeed, a useful tool.

#### Simulation in Logistics

Since World War II first highlighted the value of logistics to successful military planning, more and more mathematical and simulation modeling techniques have been applied to the logistics planning and decision-making process (Hughes, 1984:31). This increased reliance on modeling and simulation by logisticians is attributable in large part to the increasing complexity of modern weapon systems and the fast-paced, fluid nature of the Airland

Battle doctrine (Hughes, 1984:230). Today, the proliferation of PC-based simulation software presents logisticians with even more opportunity to use simulation in problem-solving efforts and, simultaneously, challenges them to do so correctly (Schenk, 1992:32).

#### Simulation of Transportation and Mobility Functions.

Within the logistics discipline, transportation problems in general and deployment problems in particular are well suited for study through simulation. Systems that are too complex to be optimized with mathematical models and are not readily available for direct experimentation are prime candidates for simulation studies (Schriber, 1991:6). Before simulation is determined to be the appropriate tool, a minimum requirement is that the modeling effort must contribute to a better decision than could be made without the model (Hughes, 1984:17).

Decision-makers often turn to simulation or mathematical modeling when

the decision maker has little previous experience making similar choices, when the alternatives are complex, or when the decision is considered important enough to expend the time and effort required to conduct extensive analysis. (Schenk, 1992:32)

Information requirements that may dictate use of simulation include: estimations of real system performance under other than normal operating conditions; evaluations of alternate system designs or parameters; or identification of effects

due solely to causal variables of interest (Kelton, 1982:8). The Pope AFB deployment information required by Air Mobility Command encompasses all of these aspects.

Existing Mobility/Deployment Models. To determine the course of simulation efforts for this study and to familiarize the researchers with the present state of logistics simulation efforts, a review of existing deployment models was required. The absence of a general-purpose model that could be tailored to the requirements of this study determined the need to construct a specialized deployment model. The review of established models and simulation studies contributed to this effort.

Although most models researched are much broader in scope (generalized) than the model required for this study, five of those strategic-level models do provide some insights into which elements within the mobilization and deployment processes are perceived to be most significant by military planners in the operations research community. Additionally, a number of special-purpose models which focus on the detailed elements of individual deployment processing systems were studied and provide insights into those variables considered significant in the more "micro-level" models that have been constructed by practicing logisticians and transportation professionals. Although the deployment systems modeled are quite different than the Pope AFB operation, these models provide specific information that is

useful in terms of model development and experimental design.

Established, Generalized Mobility Models. Three early mobility models, the Strategic Mobility Scheduling Model (SMOBSMOD), the Simulation and Gaming Methods for Analysis of Logistics (SIGMALOG) System, and the Force Interactive Response Evaluator of Assembly, Replenishment, and Mobility (FIREARM) model, focus on the ability of the aggregate logistics channel to move materiel and personnel into a specified area in a timely manner (Battilega, 1978:442-463). These models show that the focus of early efforts was on determining capabilities of the existing, aggregate transport pipeline and not on determining the resource levels required at individual hubs to make that aggregate system work at various throughput levels.

The Airlift Flow System (AFS) simulates the strategic airlift system to multiple theaters world-wide. This model uses input data on aircraft, airfields, cargo, and resources to measure the impact of constrained resources upon the airlift system (Catalog, 1988:D-2).

The Aircraft Loading Model (ALM) analyzes loadability, or the ease of loading, of military vehicles on aircraft and provides input to future airlift aircraft and military vehicle designs. This model determines the amount of airlift required to outload (process and deploy) a military force of any size (Catalog, 1988:D-4).

Relevant Special-Purpose Models. A large number of simulation studies which used specialized mobility models were reviewed for this research effort; however, only a few were actually relevant. The few studies that were selected provide a good frame of reference for this current study and are discussed briefly below. Each provides insights into either deployment system factors, model design and construction, data collection, validation and verification, experimental design, or a combination of these areas.

In one of the studies reviewed, Captain James Liggett developed a model to help facilitate efficient allocation of resources and determine extended deployment processing capabilities of a unit located at Kelly AFB TX (Liggett, 1989:5). Model development and experimentation appear to be basically sound; however, one shortfall is the apparent lack of participation by the client during model design and validation. Thomas Schriber maintains that

The probability that a simulation project (or any technical project, for that matter) will be successful will be increased significantly if time and attention are invested in the project by the client. (Schriber, 1991:11)

Liggett's thesis study uses the model to conduct two experiments. The first experiment attempts to determine the timing of the first late aircraft in a given deployment flow. The second experiment was designed to determine a realistic deployment schedule--one that could be met using

available resources--by estimating the average number of late departures during a 5-day period (Liggett, 1989:26-27).

In another simulation study of interest, Captains Michael Reusche and Vaughn Wasem developed a model to determine the manning requirement of deployable Mobile Aerial Port teams given workload data and estimated processing times for a specified deployed aerial port operation (Reusche, 1982:6-9). A number of simplifying assumptions are made in this modeling effort, ranging from motivated personnel to constant interarrival times for cargo delivery (Reusche, 1982:9-11). At first glance, many of these assumptions seemed to be a leap of faith; however, as the current study progressed, the researchers determined them to be acceptable approximations of reality and in many cases necessary to the modeling effort.

In yet another AFIT thesis reviewed, Major Thomas Christensen and Captain Gerald White used an existing model of an Aerial Port of Embarkation (APOE) base reception operation that was originally developed by First Lieutenant Larry Fortner. Their research built on the previous modeling effort through further validation of the model and substantiation of the previous assumptions (Christensen, 1983:9). They then used the model to conduct experiments designed to estimate the reception base's cargo and passenger staging capacities and to identify potential bottlenecks (Christensen, 1983:59).

The final simulation study presented here was acquired too late in the current study to be highly useful to the modeling effort of this research; however, it contains a wealth of information that cannot be omitted. The value of the results of the simulation study are, themselves, questionable since they were arrived at through one replication, using unlimited capacities for the personnel and MHE resources. However, the value of the study is its discussion of the algorithms and simulation models that have been developed over the years to gauge the capabilities of air freight resources. The thesis, written by Captain Michael Fredette, offers the most comprehensive coverage of the topic found. Of particular interest are a series of models developed during the late 1970s that used simulation to model the Dover AFB aerial port freight operation. The first two models in this series were developed by Pritzker and Associates on contract to HQ MAC (since redesignated AMC) and provided resource requirements and maximum aerial port throughput. The third and final effort in the series culminated in the Air Cargo Reception and Distribution Model (ACRDM), which uses over 90 variables and parameters to calculate aerial port throughput and resource utilization (Fredette, 1986:18-28). Fredette's coverage of those models should be used as a starting point for any future attempts at modeling aerial port operations.



## General Simulation Techniques

The literature reveals a vast array of techniques that can be used in model construction, validation, verification, and experimental design. In any particular application, the tools used will be driven by the purpose of the simulation study, the degree of confidence required in the simulation results, and the time and money available for the research effort (Sargent, 1991:37).

Model Construction. The modeling of an actual system is considered as much an art as a science (Banks and Carson, 1984:13). Osman Balci asserts that

Given a set of objectives, if ten economists are asked to build a simulation model of the U.S. economy, each one will come up with a model which will produce a different set of results. The differences in the results are considered normal and as expected under the paradigm of the art of modeling. (Balci, 1989:64)

He goes on to explain that the art of modeling is a balancing of opposites; the inclusion of essential system elements without unnecessary detail. The result when this art is properly applied is an abstraction of reality that is constructed for a specific purpose, the representativeness of which should be judged only with respect to that purpose (Balci, 1989:64).

Although no rigid rules or algorithms prescribe the method for constructing accurate simulation models, Balci provides an excellent framework from which to approach the problem. Model formulation can be described as the process

of first forming a conceptual model of the system and then sequentially transforming this concept into a communicative model, a programmed model, and then finally an experimental model. Validation is performed not as a discrete step, but continually, throughout the process. Balci's proposed life cycle of a simulation study is graphically portrayed in Figure 6 (Balci, 1989:62, 64-65).

Development of the conceptual model is the first step in the construction process. A conceptual model is the system as it exists in the mind of the modeler. During this phase, the modeler should not be encumbered by a specific simulation language as this can result in a much more complex, and thus error-prone model (Balci, 1989:62,64).

As the model is transformed into a communicative form, it is important the modeler begin with a simple model and then gradually add in the minimum complexity needed to represent the system (Banks and Carson, 1984:13). Offering a means of fitting the system representation detail to the purpose of study, Randall Sadowski states that

One technique that helps determine what needs to be included is to decompose the perceived model into smaller components; e.g., buffers, operator logic, job priorities, job release strategies, etc. Then examine each component and ask the following question: if this component is not included, will it have a significant effect on the key performance measures. (Sadowski, 1989:73)

One popular method for constructing the communicative model is through the use of a flow chart (Bobillier, 1976:36). A

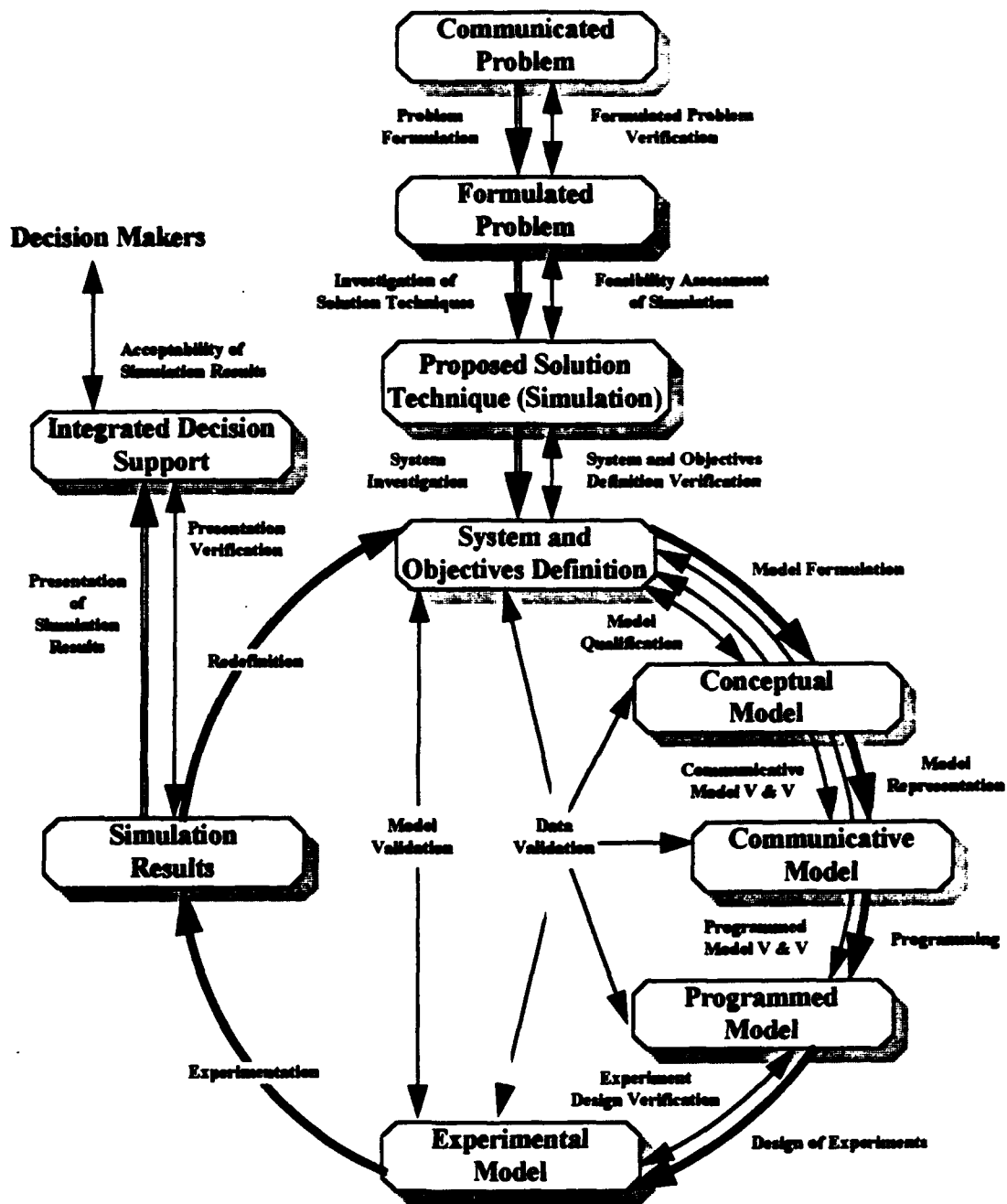


Figure 6. The Life Cycle of a Simulation Study (Balci, 1989:63)

number of other methods are also available, including pseudo code, activity-cycle diagrams, and specification of conditions (Balci, 1989:65).

Since most real-world systems exhibit random behavior, a method is needed for including this randomness when the conceptual and communicative models are transformed into the code of a programmed model. This is accomplished by either gathering data on those variable system elements and then using that data, or distributions derived from that data, as input to the model, or from one of a number of heuristic methods available. The result is either a self-driven or a trace-driven model. In a self-driven model, input values are sampled from a specified probability distribution through the use of random numbers. In contrast, a trace-driven model uses sequential data inputs directly from empirical measurement of the actual system (Balci, 1989:64).

Once the communicative model is coded into a computer simulation language and a programmed model is obtained, further coding to set up the model for a designed experiment produces an experimental model.

Verification/Validation. To ensure a simulation model provides information that is useful to decision-makers, it must do two things. First, it must be an accurate reflection of the actual system being modeled. While it doesn't have to be an exact duplication of the system, it must contain those system elements that make up the essence of the

system. This is known as validation. The model must also be constructed accurately. The logic contained in the coded model must work as intended by the conceptual model. Ensuring this proper execution of the program logic is known as verification (Schriber, 1991:11-13).

A number of methods may be used in verifying and validating models throughout development. According to Robert Sargent, models may be validated by any of the following methods:

- 1) Use of animation to observe model execution;
  - 2) comparison to previously validated models;
  - 3) degeneracy tests;
  - 4) comparing simulated events to behavior of the actual system modeled;
  - 5) extreme-condition tests;
  - 6) using judgment of system experts (face validity);
  - 7) checking model results against hand calculations;
  - 8) comparing simulation results with historical data;
  - 9) sensitivity analysis; and
  - 10) Turing tests (another use of system experts)
- (Sargent, 1991:39-40).

It is extremely important to note that Balci, among others, stresses that verification and validation should be accomplished during each phase of model construction, not just after the model has been coded. Any time code is added to or deleted from the program model, as when configuring

the model for different experiments, validation and verification should be re-accomplished (Balci, 1989:62).

### Summary

This chapter reviewed information relevant to the development of a computer simulation model of the joint deployment system at Pope AFB. First it explained general Air Force, airlift, and deployment doctrine, which explained the concept of composite wings and joint forced entry operations. Next, the review explained the deployment environment of Pope AFB and highlighted some of the limitations inherent in that environment. Current models of mobility operations were discussed next. The review concluded with a brief look at some general modeling techniques that provide a framework for this study's modeling effort.

### III. Model Development

#### Introduction

This study uses the General Purpose Simulation System/H (GPSS/H) simulation language as the medium for modeling the Pope AFB deployment system. The objective of the research is to first determine the feasibility of a joint Army/Air Force deployment from Pope AFB with the system currently in place and then look at the sensitivities of various parameters. To achieve this objective, the study includes three broad segments of work: model development, experimentation, and analysis. Due to inadequate input data and time constraints, only the airdrop portion of the model was finished and no true experimentation or analysis was accomplished.

#### Modeling Objectives and Boundaries

The first steps in developing a computer simulation model are determining what you want it to do and what the process boundaries are. Model development began with determination of the specific information desired by the Transportation Plans and Programs department at Air Mobility Command, Scott AFB, IL, detailed definition of the Pope AFB deployment system, and identification of those variables and parameters that must be incorporated in the model and those that may be excluded. Model boundaries are clearly defined and any assumptions are identified. These boundaries begin

when a passenger or piece of cargo is delivered to the aerial port and end when the aircraft blocks out (taxi away from) of its parking spot. Model development proceeds by transforming this beginning, conceptual model of the deployment system into the code of a computerized simulation model. The conceptual model was validated and the computer model was verified and partially validated. More will be said on validation and verification in Chapter 4.

### Assumptions

A number of assumptions were made in developing a model of the Pope AFB deployment operation; however, only those pertinent to the performance of the model are discussed. The major assumptions that went into model construction include the following: 1) aircraft arrive as scheduled in the Airlift Flow Plan for the exercise, 2) airdrop cargo arrives approximately as scheduled, with airland cargo arriving with slightly more variability, 3) use of 25K-loaders is preferred in the DACG airdrop operation, while use of 40K-loaders is favored in the 23rd Wing mobility machine and the DACG airland operation, 4) all airdrop cargo is shuttled from the scales directly to the highlines, 5) all cargo and passenger processing times, excluding the time required to correct frustrated cargo, follow a triangular distribution, 6) frustration times are uniformly distributed, 7) unlike the airland cargo, airdrop platforms



are not frustrated, 8) TAC Loaders, which are basically K-Loaders designed for tactical use on unimproved surfaces, are not differentiated from 25K-Loaders, and 9) all highlines and rollerized flatbeds are lumped together in a common pool of storage space. These assumptions were discussed with experts who routinely work within the Ft Bragg/Pope AFB DACG and wing mobility operations and were determined to be valid (Rogers, 20 March 1993).

Assumption 1. The first assumption, that airlift arrives as scheduled, is a very likely occurrence for the Pope AFB operation in this scenario. Even during past major contingencies or wartime situations when the airlift system was strained to maximum capacity, the highest airlift priority was given to the rapid insertion forces of the 82nd Airborne Corps. Thus for the joint deployment scenario of the exercise, it is highly likely that the required airlift will be available. That this airlift will arrive on time is not so certain since aircraft are subject to maintenance, weather, or a host of other problems. Variability in aircraft arrival could be added to the model at a later date; however, the researchers do not feel this is an intrinsic part of the cargo and passenger processing system. If for some reason no aircraft arrive, cargo and passengers in the actual system would continue to process until all storage space is utilized; at that time the system will stop. In a dense flow of similar aircraft, such as the one

planned for Pope, one late aircraft will merely cause the chalk planned for that aircraft to be loaded on the next arriving aircraft.

Assumption 2. That airdrop cargo arrives at the scales in approximate chalk (aircraft load) order and close to the scheduled scale time probably seems to be a weak assumption to anyone who has participated in a mobility exercise, but due to the unique nature of deployment operations at Pope AFB it is a reasonable assumption. Increments on airdrop platforms cannot be stored on the ground because they cannot be picked up and transported with a 10K forklift as can regular 463L pallets. This in effect forces the platforms to be stored on either K-Loaders, highlines, or rollerized flatbed trailers. Since all three types of equipment are in short supply at Pope AFB, and the K-Loaders are needed to load aircraft, it is imperative that airdrop cargo be delivered by units at or near the scheduled times. If it does not, the storage space could be taken up by cargo that is not departing until much later. If this were allowed to happen with any regularity it would tie up the scales and platform storage equipment, thus making it impossible to weigh and set up higher priority cargo arriving after the out-of-sequence cargo.

Airland cargo will tend to arrive more randomly than airdrop cargo with some increments arriving potentially very late. The main reason for this is that the buildup and

delivery of airland cargo is not as strictly controlled as it is for airdrop cargo. This randomness is modeled by having slightly more variability in the arrival times for airland cargo. Airland cargo, both rolling stock and palletized, can be stored on the ground in the marshaling yards so it won't tie up constrained MHE while in storage. In those instances where cargo shows up very late, it is usually bumped off the chalk and replaced with other cargo so it won't delay aircraft departure. It would be extremely difficult to simulate increments being swapped from one chalk to another and very little authenticity would be gained relative to the amount of additional model detail required. For the most part, cargo will arrive approximately in chalk order. Whether or not the cargo within that chalk is in the same order as load planned has little or no effect on model or actual system performance. Replacing very late increments will cause disturbances in load planning and paperwork, but for the most part would not affect on-time aircraft departures.

Assumption 3. The assumption dealing with K-Loader usage is driven by the limitations in the GPSS/H language against looking backward or forward in time. GPSS/H can only act on what is occurring in the model at the present time; it cannot be made to think like a person in planning for future events. In order to exactly model the decision-making process of determining whether to use a 10K forklift,

a 25K-Loader, or a 40K-Loader for a given chalk, the program needs to be able to "see" not just the increment of cargo currently being processed, but all of the increments that follow for at least the next four or five chalks. Since the model could not see into the future, a DACG bias for 25K-Loaders and an Air Force mobility machine bias for 40K-Loaders was purposely built into the model. For routine operations in the scenario under study, this bias does generally mirror the actual decision-making process. Since much of the cargo moving through the DACG operation will be too heavy for a 25K-Loader, personnel in charge will tend to use 25K-Loaders for any cargo increments that will fit on one and save the 40K-Loaders for those increments that won't fit on a 25K-Loader. Meanwhile, in the 23rd Wing mobility operation, most of the cargo will be standard sized rolling stock or 463L pallets which will easily fit on either a 25K- or 40K-Loader. In this situation, the decision-maker would choose to use a 40K-Loader first, as long as other increments on the chalk would fill up the rest of the loader. This would reduce the number of pieces of MHE necessary to load the aircraft. These built in biases are an acceptable tradeoff. While the K-Loader loading segments of the model will not accurately represent all MHE decisions, they will accurately represent the more routine ones.

Assumption 4. To simplify model construction the assumption is made that all airdrop platforms will be shuttled directly from the scales to the highlines since that is what happens most of the time during a large scale deployment. After the first few chawks have been through the scales the MHE gets tied up with cargo, so in order to keep the scales busy the airdrop platforms are stored on highlines or rollerized flatbeds. Since airdrop platforms must be stored on highlines, rollerized flatbeds, or K-Loaders, and K-Loaders are needed to load the aircraft, the platforms are stored on the highlines or flatbeds until load time. The scale/crane combination is a capacity constrained resource and as such should be kept busy at all times. By moving the platforms directly to the highlines or flatbeds instead of waiting for K-Loaders, the scale is kept busy, at least until all highline and flatbed space is taken and all K-Loaders are in use. For modeling purposes, rollerized flatbed storage space is grouped with highline space since both provide the same service: storage for airdrop platforms.

Assumption 5. Due to problems experienced during the data collection process, the amount of data required to develop the actual distributions of many stochastic model elements was not obtained. In fact the volume of data required for this effort could be a research study in itself. As an acceptable, and intuitively appealing

approximation, all of the cargo and passenger processing times, with the exception of correcting frustrated cargo, are drawn from triangular distributions that were fit from the available data, as well as interviews with system experts. At least for the DACG operation, which is the operation of most concern among planners, these distributions should be very near reality. Air Transportation personnel, not augmentees, man the weighing, Joint Inspection (JI), MHE operation, and aircraft load team supervision positions within air terminal services section. As a result of this expertise, for a given type of equipment the required processing time will vary only slightly, with no extreme measurements; hence a triangular distribution. In a triangular distribution the modeler determines the minimum, maximum, and mode times from the raw data and then enters them into the model using the built in GPSS/H RVTRI function. The model draws numbers from a random number generator and uses these numbers to assign processing times. While the assumption of triangular distributed processing times may not be as precise an approach in the Air Force mobility segment, it is felt that degradation of model accuracy will be minimal.

Assumption 6. Cargo frustration times (the time needed to correct discrepancies found during joint inspections) are modeled as uniformly distributed because frustrated

increments exhibit a very wide range of possible correction times, each with an equal probability of occurrence.

Assumption 7. It is assumed that airdrop loads aren't frustrated. Although most transportation personnel, due to their familiarity with Air Force mobility, may find this assumption odd at first glance, it is a very accurate assumption. This is due to the importance placed on properly rigging airdrop loads. Any time a 30,000 pound piece of cargo is extracted from an airborne aircraft the potential for disaster exists. Airdrop operations even with properly rigged loads are dangerous; with improperly rigged loads, they can be deadly. Because of this, these loads receive special attention from the initial build-up of the increment to final loading and the subsequent Joint Airdrop Inspection (JAI). Deficiencies receive a high priority and are corrected quickly without "officially" frustrating the increment. The airdrop segment of the model contains a mechanism which would allow the modeler to frustrate the increments by changing the frustration probability in the input data processing times matrix from zero to some other number.

Assumption 8. The assumption that TAC Loaders are considered the same as 25K-Loaders is probably the most limiting assumption made. While TAC Loaders have more capabilities than 25K-Loaders (a TAC Loader with an extender can carry 4 pallets and 30,000 pounds, while a 25K-Loader

can carry only 3 pallets and 25,000 pounds), the additional detail needed to include them in the K-Loader selection logic and the extra debugging needed are prohibitive due to the time constraints in model construction. The assumption seems more reasonable when you consider that the superior loading capabilities of the TAC Loader are somewhat offset by its lower Vehicle in Commission (VIC) rate and higher shop time per vehicle (84.0% VIC for TAC Loader vs. 97.8% VIC for 25K-Loader and 8.4 days shop time for TAC Loader vs. 3.8 days shop time for 25K-Loader) (Grafton, 21 April 1993).

Assumption 9. Pope AFB has 3 covered and 6 uncovered highline docks along with access to several rollerized flatbed trailers, all of which are used to store airdrop pallets. While each of these docks and trailers are separate entities, modeling them as such would be extremely difficult and not add to model validity. While chalk integrity is maintained in the real system, the concern here is on total platform storage capacity, not the order in which increments are stored.

Data. The model requires a large amount of input data, both for the stochastic processes of the model as well as for the individual units of traffic that move through the model during simulation of a specific scenario. As previously mentioned, problems in data collection resulted in some required tradeoffs in model accuracy. These tradeoffs relate only to the model elements that draw random



numbers from a distribution predicated on that input data. The output data of interest are the number of late aircraft departures and the mean tardiness. Actual model output consists of actual terminal complete times, which are the times at which aerial port personnel complete loading of all passengers and cargo, and the scheduled terminal complete times. The parameters in the model were systematically changed during verification efforts to determine the effect of these changes on the time the chalk was terminal complete. The scheduled terminal complete time is 30 minutes prior to scheduled departure time.

The input data are contained in three trace files which drive the deployment simulation model. The information from these trace files is either assigned to the "Xacts", which are transactions representing aircraft or increments, or read into a data matrix for use in the model. The first trace file in this model is called LDINFO.TXT (Appendix E) and it contains chalk number, mission number, number of increments, scheduled departure time, branch of service, and aircraft type for each aircraft load. This information is assigned to the lead Xact which represents the aircraft itself. This file was built using information contained in the Airlift Flow Plan and aircraft load plans for the joint deployment exercise. The model uses this information to schedule increment creation and to determine how many increments to create for each chalk. Each line in this file

is for a separate chalk with the first column being the chalk number and the second column the mission number. The modeler needs to assign a chalk number to each of the missions in order of their departure time. The third column contains the number of increments on the chalk. This number is derived from load plans for each chalk. If there are passengers on the chalk they are modeled as one increment regardless of the number. The number of increments column is used to determine how many increments to create when the lead Xact is split. The fourth column is the departure time of the chalk. It is one of the most important pieces of information that each increment will carry with it, since everything in the process revolves around aircraft departure time. The fifth column contains a code for the branch of service for the chalk. Air Force loads are coded as a 100 while Army loads are coded as a 300. These codes are used to direct each increment to the correct model segments for processing. The sixth column specifies the type of aircraft each chalk is to be loaded on. A 005 in this column specifies the chalk is to be loaded on a C-5, while a 141 designates the chalk as going on a C-141. All the information needed for this file, with the exception of the number of increments, was found in the Airlift Flow Plan for the joint exercise.

The model gets increment specific information through the input trace file called LDPLANS.TXT (Appendix F). The

increment Xacts are created after the lead Xact goes through the split block. These increment Xacts pull information sequentially from this file, so it is important the files are arranged in the correct order. Each line in this file contains the increment number and type of load for that increment. The airdrop portion of this file was created using load plan information provided by the 82nd Airborne Division. At the time of model construction neither the Army nor Air Force had developed load plans for their airland portions of the exercise. The modelers developed Air Force load plans for the joint deployment by fitting current 23rd Wing deployment load plans, which use C-141 aircraft exclusively, to the flow for the exercise. Army airland load plans were constructed by subtracting the amount of cargo deploying via airdrop from the total equipment shown in the Deployment Ready Brigade Equipment Listing and putting it on chawks according to priorities listed by Maj Young, Army Ground Liaison Officer (Young, 19 March 1993). The first column in each line specifies the increment number for each piece of cargo, while the second column indicates what specific type of cargo it is. The third column shows the chalk number for each of the first increments. This data is used only to aid in building and troubleshooting the file and is not read by the computer since it is separated from the second column by more than one space.

The final trace file needed to run the model is the increment data matrix file PROCTYM.TXT (Appendix G). This file contains the following information, in column order, for each of the increment types: increment type code, weight, number of pallet positions taken up by cargo, minimum weigh/JAI/JI time, maximum weigh/JAI/JI time, mode weigh/JAI/JI time, minimum loading time, maximum loading time, mode loading time, cargo type code (pallet=1, rolling stock=2, airdrop platform=3, passengers=4), frustration probability, and increment type description. The last column, containing the increment type description, is used for reference only and is not read by the computer. The increment data matrix for this model contains 108 rows with each row corresponding to an increment type being transported in the joint deployment. Additional increment types could be added to the matrix as long as the statement defining the matrix in the model is changed accordingly. Passengers are not modeled individually in this model, but rather in groups of 100, 75, 50, 25, or 10. They are included in the increment data matrix file but have zero values in the areas that are not applicable, such as weighing and frustration probability. The weight of each increment type is derived from load plans or standard planning data weights. The pallet positions taken up by the cargo are determined by dividing the length, which is also in the load plans or standard planning data, by 88 inches.

If the increment is narrower than a 463L pallet, for example a C-130 towbar, then the modeler divides by 88 inches and makes an allowance for the narrower width. Due to problems in data collection, the values in the increment data matrix file are somewhat suspect. More is said on this in the variables segment.

Parameters. The parameters used in the model, which are elements that do not change during a model run, such as the number of highlines or 40K-Loaders available, are selected using the modelers' past experience with the Pope AFB mobility system and expert opinion from current 3rd Aerial Port Personnel (Rogers, 20 March 1993). The following parameters are used in the model: number of roll on/off scales, amount of highline/rollerized flatbed space, number of 40K-Loaders, 25K-Loaders, and 10K forklifts, pallet positions of storage space in the Army Call Forward Area and Air Force marshaling yard, and the number of joint inspectors, MHE operators, loadmasters, and Aerial Port load teams.

Not every parameter of the real system is included in the model because the excluded parameters would not add appreciably to model performance and validity. Examples of real system parameters that the modelers and system experts feel are insignificant to modeling the cargo and passenger flow during a deployment exercise are: number of load planners, size of the Army load team pool, explosive cargo

storage space and aircraft parking hot spots. Prime movers, vehicles that pull or push trailer type pieces of rolling stock onto an aircraft, are excluded from the Army airland deployment section of the model because most trailers are transported attached to a prime mover. The paperwork for a load is not considered a system constraint so the number of load planners is not an important parameter. The Army load team pool is a group of nondeploying Army personnel used to assist the Air Force load team in pushing airdrop platforms onto the aircraft and in securing loads to the cargo floor. The load team pool was not modeled as a parameter since the Army can always provide an adequate number of team members. Explosive cargo storage space and aircraft "hot spot" parking are not included as parameters because during a contingency the special storage and aircraft parking requirements for explosive cargo can be waived. The extra time that it takes to transport cargo to the hot spot is included in the loading time distributions.

Variables. The model variables are processes that cargo increments go through from entry into the mobility system until loading onto an aircraft. The variables can take on a range of values. Some variables are cargo specific, like the time it takes to load a specific piece of equipment, and some are general, for instance, the time it takes to drive a K-Loader from the scales to the highline docks. The cargo specific variables are assigned to each

increment type through a matrix file. The cargo specific variables of interest used in the model are the weigh/JAI times for each increment type and the time it takes to load each type on the aircraft. As was mentioned earlier, these variables are assumed to follow a triangular distribution, although not enough data were collected to prove a true distribution pattern for any of the increment types.

The model contains many general variables which apply to every increment, regardless of the type. The general variables in the model are as follows: the time to move a piece of MHE or rolling stock from the scales to the highlines or staging area, cargo frustration times, time to push an airdrop platform from a K-Loader to the highline or rollerized flatbed, time to push platform from the highline or rollerized flatbed to a K-Loader, time to drive a piece of MHE or rolling stock from the highlines or staging area to an aircraft, time to position a K-Loader behind an aircraft, and the time for an aircraft to block out of its parking spot. The modelers obtained times for these variables of interest, but not enough to construct valid distributions. For simplicity these general variables are assumed to follow a uniform distribution.

### Summary

This chapter first explains modeling objectives and boundaries. Next it discusses assumptions made about the

Pope AFB deployment environment to facilitate model construction. The input data required to drive the model and the output data produced are then described in detail in the following section. Finally the parameters, such as MHE and manpower availability, and variables, such as cargo weighing and loading times, are listed and defined.



## IV. Model Validation

### Introduction

This chapter discusses model validation and verification efforts and identifies the limitations or shortcomings of the deployment model. Model validation is a continuous process that occurs throughout all stages of model building (Balci, 1989:65-68). The first validation stage is the process of determining if the conceptual model is a suitable representation of the real system, while the final stage is to determine if the computer model behaves like the real system. Model verification is the process of assuring the conceptual model is correctly converted to computer code (Schriber, 1991:13).

### Validation

Efforts at model validation occurred throughout model development. During the data collection effort, a preliminary validation was performed to ensure the conceptual model accurately represented the deployment system. This was accomplished through an in-depth comparison of the conceptual model flowcharts and the actual system by experienced air freight/passenger specialists assigned to 3 APS at Pope AFB (Rogers, 16 March 1993). Further validation was to be done by comparing the verified computer model to the real system. To accomplish this the modelers obtained an AF Form 68 from a day when the Pope AFB

outload system was extremely taxed with both airland and airdrop missions. The AF Form 68 is a log kept by the Air Terminal Operations Center which contains data pertaining to missions handled by the aerial port for that day. Data included in the AF Form 68 are: scheduled and actual aircraft arrival and departure times, scheduled and actual cargo and passenger loading times, scheduled and actual cargo inspection times, and load plans. From this data the modelers were to make trace files from the actual exercise and run them through the model to see if the model performed as the actual system had. This validation effort was not completed because the data gathered during time studies was incomplete on most increments and nonexistent on the rest.

#### Verification

After the airdrop portion of the conceptual model was converted into computerized form, the verification phase began. The modelers encountered many problems in this phase and were forced to step through small segments of the model due to its complexity. By stepping through each of the model segments in the test mode of GPSS/H, the modelers were able to debug logic errors and eventually verify that the logic accurately mirrored the conceptual model. After this step was completed, the modelers moved to the next verification step; determining the sensitivity of the model to changes in input parameters.

The sensitivity analysis was accomplished to determine if the model reacted as the real DACG operation would to changes in potential bottleneck parameters. The modelers conducted several runs of one replication each with varied sets of input parameters. The parameter sets used, as well as the results of these runs are shown in Table 3. Although

TABLE 3

SIMULATION RUNS USED IN VERIFICATION

	<u>40K</u> <u>Ldrs</u>	<u>25K</u> <u>Ldrs</u>	<u>H-line</u> <u>Space (PP)</u>	<u>Scales</u>	<u>Late</u> <u>Departures</u>	<u>Mean (min)</u> <u>Tardiness</u>
Treatment 1 Baseline	8	15	100	1	37	596.7
Treatment 2 Fewer K-Ldrs	6	12	100	1	36	597.7
Treatment 3 Increased K-Ldrs	12	20	100	1	37	597.0
Treatment 4 Increased H-Lines	8	15	200	1	37	596.7
Treatment 5 Increase scales	8	15	100	2	34	229.1
Treatment 6 Increase All	12	20	200	2	30	145.3
Treatment 7 Scales to 3	12	20	200	3	19	68.0

PP = Pallet Positions

one replication isn't adequate for basing policy decisions, it served to roughly test sensitivity.

The first four treatments failed to provide results of any meaningful significance. The first treatment in these sensitivity experiments was run under current conditions at

Pope AFB and was considered the baseline. This treatment resulted in 37 late departures and a mean tardiness of 596.7 minutes. The second treatment was with decreased K-Loader capacity. This treatment yielded 36 late departures and a mean tardiness of 597.7 minutes. The third and fourth treatment, like the first two, resulted in no significant change in the number of late aircraft departures or in mean tardiness. Treatment three increased the number of K-Loaders available over the current Pope AFB conditions, while treatment four kept all the parameters at baseline levels except the amount of highline/rollerized flatbed space, which was increased from 100 pallet positions to 200 pallet positions. This result seems to indicate that K-Loaders and highline docks probably were not the constraining resources at the baseline level.

While the first four treatments produced insignificant results, the last three treatments produced results that were not only significant, but also in line with expected system behavior. Treatment five kept all parameters except the scales, which were increased from 1 to 2, at baseline levels. This treatment produced three less late departures and reduced mean tardiness by 367.6 minutes. This indicated that the scales were a capacity constrained resource, a conclusion already reached by the Joint Deployment Study group and other past studies (Joint, 1990:86). The sixth treatment was run with the scales set at 2 and all other

model parameters at increased levels. This treatment resulted in 4 less late departures than treatment 5 and reduced mean tardiness by 83.8 minutes over the previous treatment. The seventh treatment was the same as treatment six except that the number of scales was raised to 3. This treatment reduced late departures by 11 and decreased mean tardiness by 77.3 minutes in comparison with treatment 6. This indicates the scales were still a capacity constrained resource at this parameter level combination. It is important to realize that these results do not indicate what is needed to successfully deploy the airdrop portion of the DRB under the joint deployment exercise. These results only indicate the model is exhibiting the expected behavior to changes in model parameters and leads the researchers to believe the model logic accurately represents the conceptual model. To make any prediction of required resources, this model would have to be completely validated and driven with more accurate input distribution data built using comprehensive time studies.

### Limitations

As mentioned previously, due to time constraints several planned segments of the model were not completed and final validation of the completed airdrop portion of the model could not be done due to inadequate time studies. Due to these limitations the modelers concentrated on the area

of most concern to Army and Air Force planners: the airdrop of the Alpha echelon of one DRB. The airland portion of both the Air Force and Army deployment operations has been completed up to the MHE selection point. Another unfinished model segment is passenger processing, although the passenger loading segment is complete. Until these segments are completed the model can only be used for airdrop cargo loads. Since the airdrop loads were all departing on C-141 aircraft only the C-141 aircraft loading segment was completed. The C-5 aircraft loading segment, which would have allowed two K-Loaders to simultaneously load an aircraft, was not started. The modelers obtained MHE reliability information but did not have time to add MHE breakdowns to the deployment model. Since MHE is maintenance intensive, the addition of the breakdown logic is a must to make the model a valid abstraction of the actual system. The fact that this model, as is, should not be used for policy decisions cannot be overstated. The model will not be a useful tool unless and until all of the limitations noted above have been overcome. The next chapter provides the modelers' recommendations for completing for completing the planned simulation study.

## V. Recommendations for Future Research

### Introduction

This chapter discusses the actions necessary to complete the construction and validation of the deployment model started by this research. First, a comprehensive time study is required to ensure the input data distributions the model uses are accurate. Next, seven more sections of code need to be completed. Finally, the model must be verified and validated. Once these steps are accomplished, the result will be a model that may be used by decision-makers to help determine the manpower and equipment requirements for a major deployment of any unit from any Air Force base.

### Comprehensive Time Study

The first, and probably most time consuming effort required is a comprehensive time study of cargo processing times. These times should include: joint inspection times, weighing times, set-up times, and loading times at a minimum. In the case of airdrop loads, pre-joint airdrop inspection/weigh times must also be included. These times should be compiled for each major type of cargo increment. To be useful in determining the appropriate distributions to build, the data must not be averaged; however, slightly aggregating the data into small time buckets would have the effect of providing a useful histogram. The increment types that need to be researched in this time study are listed in

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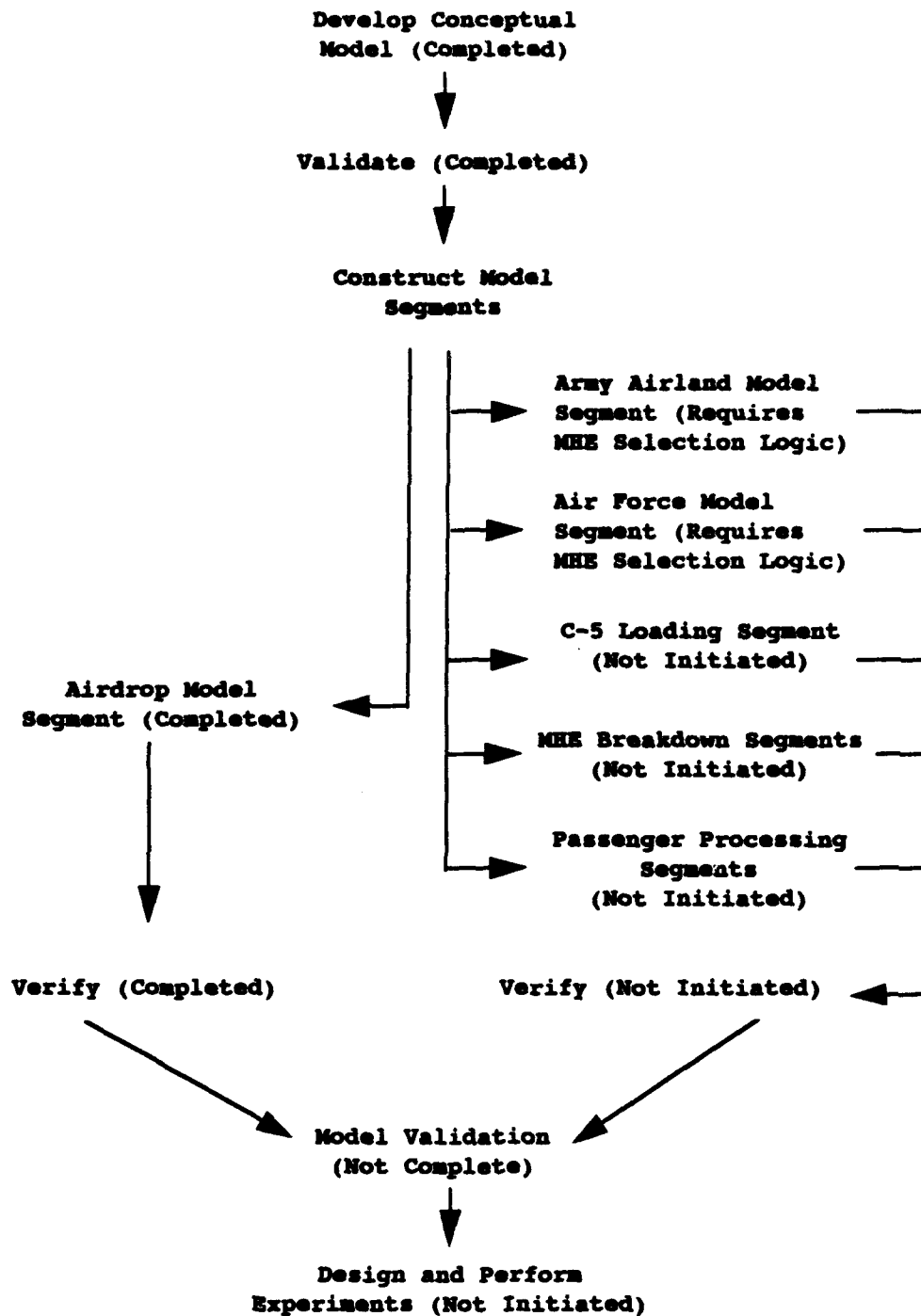


Figure 7. Model Development Status Diagram

Army and Air Force Airland Segments. The increment arrival, weighing, and inspection segments for both the Army and Air Force have been completed, but both need to have MHE selection logic added. Parts of the DACG airdrop MHE selection segment may be used for the airland MHE selection segments, although care must be taken in doing this since there are many differences between the two operations that require different logic. First, the same basic K-Loader selection logic used in the DACG airdrop segment can be used here, but since the Army and Air Force airland operations will be biased in favor of 40K-Loaders instead of 25K-Loaders, the order of K-Loader type attempted first is reversed. This may be accomplished by sending airland increments through the same MHE selection logic but using different Boolean variables for MHE selection. This is but one of the possibilities for finishing the Army and Air Force airland load processing model segments.

Equipment Breakdown Segment. The MHE used in the deployment of forces from Pope AFB is prone to mechanical breakdowns. Since this is an intrinsic part of any deployment process, mechanical failures must be included for the model to be an accurate representation of the real deployment system. This should not be too hard to accomplish. Figure 8 portrays one possible approach. Transactions representing MHE breakdowns are created and

	GENERATE	0,,, &KLOADR40
INCOMM40	ADVANCE	RVEXPO((random number stream),_ (mean time to failure for 40Ks))
	ENTER	KLOAD40
	ADVANCE	RVTRI((random number stream),_ (min repair time), (mode repair time)_ , (max repair time))
	LEAVE	KLOAD40
	TRANSFER	, INCOMM40

Figure 8. Suggested Code for Modeling Equipment Breakdowns

then occupy MHE for an amount of time equivalent to real world repair time. These times should be derived from studies during surge outload conditions.

C-5 Loading Segment. In order for the Army and Air Force airland segments to function properly, a C-5 aircraft loading segment needs to be accomplished. This segment could be patterned after the C-141 aircraft loading logic. The only differences are that two K-Loaders can load at one time with a C-5 and the time it takes to position K-Loaders behind the aircraft is longer.

Passenger Processing Segments. The processing of passengers is not considered as big a system constraint as the scales and highlines, but in order to represent the total deployment environment and make the model of use in generalized deployment scenarios it needs to be included. Two separate segments of code will need to be added since

Army and Air Force passenger processing are independent of each other.

Run Control Segment. This segment will be required before the model can be used for experimentation. To attain the desired confidence level, a number of simulation runs (replications) must be performed for a given parameter set. The run control logic can specify the number of replications necessary to analyze a specific parameter set, automatically switch between parameter sets, or perform a number of other control functions that help turn simulation output into meaningful information.

#### Complete Model Validation

Once all model segments have been completed and the entire model verified, then final model validation can begin. As was mentioned in Chapter 4, the modelers planned to use an AF Form 68 from a past large deployment to create trace files to run in the model. These trace files would then be run for a predetermined number of replications to achieve the desired accuracy. The results from these runs would be compared to actual departure times from the AF Form 68 to see if the model behaved as the real system. To validate that the model generalizes to other deployment operations throughout the Air Force, these same type runs would have to be accomplished with data from AF Form 68s

from several different Air Force bases under widely varied conditions.

#### Model Use

At this time it would not be appropriate to use this model for policy decisions; however, upon completion of the actions specified above, this model potentially could provide information on personnel and resource requirements across a broad spectrum of deployment conditions. This would be a definite improvement because the air transportation community has no such tool to assist in decision making at the current time in spite of numerous previous attempts (Coker, 15 January 1993). This model could potentially size the air transportation resources required to support any future contingency operation. The payoffs to further research would be well worth the effort.

To use this model, planners would need a basic understanding of GPSS/H, statistics (confidence intervals in particular), and a full-up version of the GPSS/H simulation language. In order to run the full-up version of GPSS/H, at a minimum a 386DX PC with 4 Mb of RAM is required. Prior to attempting to run this model several trace files must be constructed. See Chapter 3 for instructions. Once GPSS/H is loaded on an appropriate platform and the trace files have been constructed, the program is started by typing "GPSS/H (filename.GPS)" at the "C>" prompt. At the present

time the model filename is "DEPFIN.GPS"; however, this model name may be changed in future modeling efforts. After initiating the program, the user will be prompted to enter values for MHE, storage space, and critical personnel. Once these values have been entered the computer will return to the "C>" prompt. At this time model execution is complete. Refer to GPSS/H users manual for details on output options.

### Summary

While this research has been hindered by data collection problems and modeling difficulties, it has been successful in setting the stage for establishment of a generalized mobility model capable of sizing the air transportation support requirements at a single base. The model segment completed displays the expected sensitivities and shows promise that this research has identified a fruitful area for further research. A major difference between this model and many past efforts is that it is driven by data from the actual deployment being planned. Because of this, the model may well provide more accurate information than that normally attained from a generalized model. In effect, it will be possible to customize the finished model to fit any deployment scenario.

## Appendix A: Glossary of Technical Terms

**AIRDROP PLATFORM** - Aluminum platforms of varying lengths for different cargo types, designed to lock into the 463L rail system of military transport aircraft. The cargo is secured to the platform and usually has some type of shock absorbent material between it and the platform.

**AIRLAND CARGO** - Any cargo which will be unloaded while the aircraft is on the ground. Can be rolling stock, palletized, or floor loaded cargo.

**AIRLAND OPERATIONS WING (ALOW)** - A new concept in which a composite Air Force wing is designed specifically to deploy with and support Army ground forces.

**AIRLIFT FLOW PLAN** - Detailed schedule of planned exercise that lists the mission number, aircraft type, configuration, aircraft operator, arrival date and time, destination, departure date and time, reason for stop, user of aircraft, amount of passengers off/on, bulk cargo off/on, oversize cargo off/on, outside cargo off/on, aircraft ground time, and flying time.

**ALERT HOLDING AREA** - An area used to stage cargo prior to the joint inspection. Used with an A/DACG operation.

**CALL FORWARD AREA** - An area used to stage cargo after the joint inspection and prior to aircraft loading. This area is also used with an A/DACG operation.

**CHALK** - Aircraft load designator. While the term line refers to a specific aircraft, the term chalk refers to a specific load of cargo. Aircraft chalks are then assigned to a line, resulting in an airlift mission, but can be swapped between lines.

**CHECKPOINT** - The name for the terminal services function at Pope AFB. Checkpoint performs all cargo inspection and loading functions and is in charge of loading Army passengers.

**COMPOSITE WING** - An Air Force wing in which dissimilar aircraft are combined into one wing.

**DEPARTURE AIRFIELD CONTROL GROUP (DACG)** - Organization which is responsible for coordinating unit moves and solving any problems encountered with deploying unit's cargo or passengers during a contingency or exercise. It is the liaison between the Air Force and the deploying unit. The branch of the service that composes the majority of the

deploying forces is responsible for providing the DACG. At Pope AFB the DACG is composed of Army personnel.

DEPLOYMENT READY BRIGADE (DRB) - An Army brigade that is ready to deploy immediately upon the outbreak of hostilities. They are "locked and loaded" so to speak.

DUNNAGE - Piece of wood, usually 4"x4", used to support a pallet when stored on the ground. Three pieces of dunnage are required per pallet. Dunnage protects the thin aluminum pallet skin from damage and allows forklifts easy access.

EXTRACTION CHUTE - Small parachute attached to airdrop loads which extracts load from aircraft. Once the airdrop platform has cleared the aircraft the main chutes open and control the platform's descent.

FRUSTRATED CARGO - Cargo which has a discrepancy, discovered during joint inspection, preventing it from being transported on Air Force aircraft. Cargo is considered frustrated until owning unit corrects discrepancy.

GPSS/H - A discrete event, general purpose computer simulation language that is useful for modeling systems composed of units of traffic that compete with each other for scarce resources.

HIGHLINE DOCKS - A rollerized dock which will hold 10 pallet positions of airdrop platforms or 463L pallets. Built at K-Loader height to ease loading/unloading operations.

INCREMENT - Each piece of cargo for a chalk is a separate entity or increment. Passenger loads are considered an increment in the computer simulation deployment model for this research.

INTEGRATED OPERATIONS CONCEPT FOR CORPS ELEMENT AND AIRLAND OPERATIONS WING (CCW) - A concept of operations that is still under development, which pairs an ALOW with an Army Corps element in forced entry operations.

JOINT AIRDROP INSPECTION (JAI) - Inspection accomplished to ensure airdrop platform is ready for airlift and properly rigged for airdrop operations. The inspection is performed by an Air Force loadmaster and a deploying unit representative.

JOINT INSPECTION (JI) - Inspection accomplished to ensure airland cargo is ready for airlift. The inspection is performed by a JI qualified Air Force member and a deploying unit representative.



**K-LOADER** - Type of MHE used to transport and load multiple pallets onto aircraft or highlines. An integral part of the 463L system.

**LOAD PLAN** - Document, usually computer generated, which shows the position in aircraft, weight, and dimensions of every increment on a chalk. Also shows passenger load information.

**LOAD SET-UP** - Activity of positioning increments on K-Loaders in the order in which they will be loaded on the aircraft.

**OUTLOAD** - Process by which a deploying unit's cargo and personnel are checked to ensure they are deployment ready and uploaded on departing aircraft or other mode of transportation.

**PALLET, 463L** - Standard Air Force pallet for building up and transporting cargo. Made with an aluminum skin laminated over balsa wood. Designed to lock into the rail system of military transport aircraft. These pallets, along with the side and top nets, straps, and chains and devices used to secure cargo to the pallet, are an integral part of the 463L system which consists of the roller systems on aircraft, rollerized docks, forklifts, and K-loaders.

**PARAMETERS** - System attribute that does not vary during a certain period of time. In this research, a parameter is an attribute that remains constant throughout one simulation run, such as the amount of MHE available.

**PRIME MOVERS** - Vehicle used to transport and to load/unload non-powered rolling stock.

**RANDOM NUMBER GENERATOR** - An algorithm that generates a pseudo-random stream of numbers. For all practical purposes, this stream is a list of random numbers.

**READY LINE** - The point at which control of cargo passes from the deploying unit to the airlift managing agency. At a base with an organic airlift command and control function, this will be the assigned aerial port squadron, otherwise it will be an airlift control element.

**ROLLERIZED FLATBED** - A flatbed equipped with rollers that can accommodate 463L pallets or airdrop platforms.

**ROLLING STOCK** - Any wheeled equipment that is not secured to a 463L pallet.

**STATION ACTIVITY REPORT** - Scaled down version of the airlift flow plan. Does not contain complete mission itinerary or user information.

**STOCHASTIC PROCESS** - Any process that contains some degree of randomness.

**TACTICAL LOADER** - Type of K-Loader that operates on unimproved surfaces.

**TERMINAL COMPLETE** - Time when aerial port personnel have completed all cargo and passenger loading operations.

**TRACE FILE** - An input file from which data is drawn as needed by a computer simulation model.

**TRIANGULAR DISTRIBUTION** - A distribution with a probability density function in the shape of a triangle. The function is defined by the minimum, mode, and maximum values for the distribution.

**UNIFORM DISTRIBUTION** - A distribution in which all values have an equal probability of occurrence. Defined in GPSS/H by the average and the half-width of the range.

**VALIDATION** - Determination that a model is an accurate representation of the actual system being modeled. The right things are being measured.

**VARIABLE** - System attribute which varies over a specific period of time. In this research, a variable is an attribute that changes during one simulation run, such as loading times.

**VERIFICATION** - Determination that the computer model has been coded correctly. The measurement tool is working properly and taking accurate measurements.

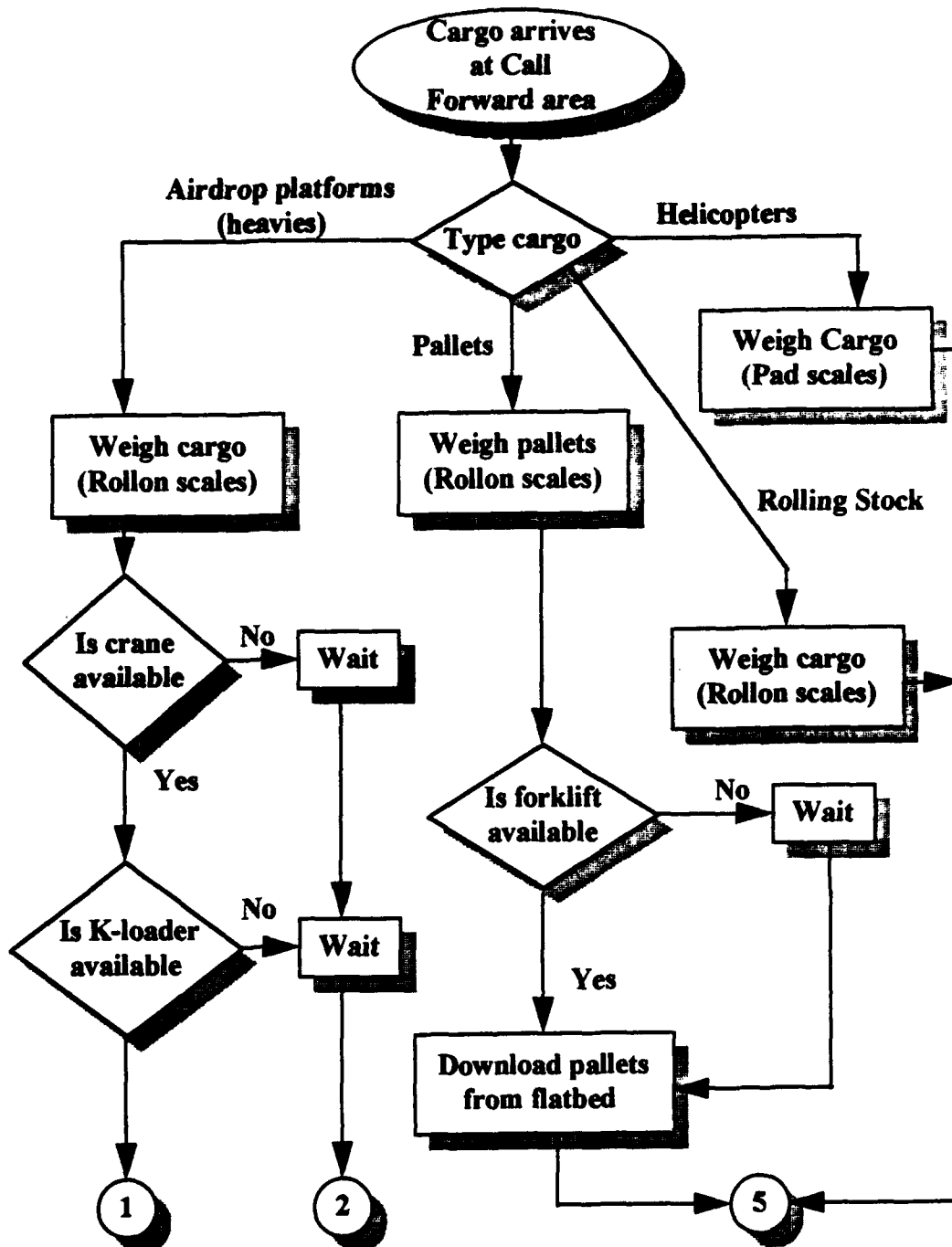
**XACT** - An abbreviation for a transaction, which in GPSS/H represents a unit of traffic that flows through the model and competes with other transactions for the use of scarce resources.

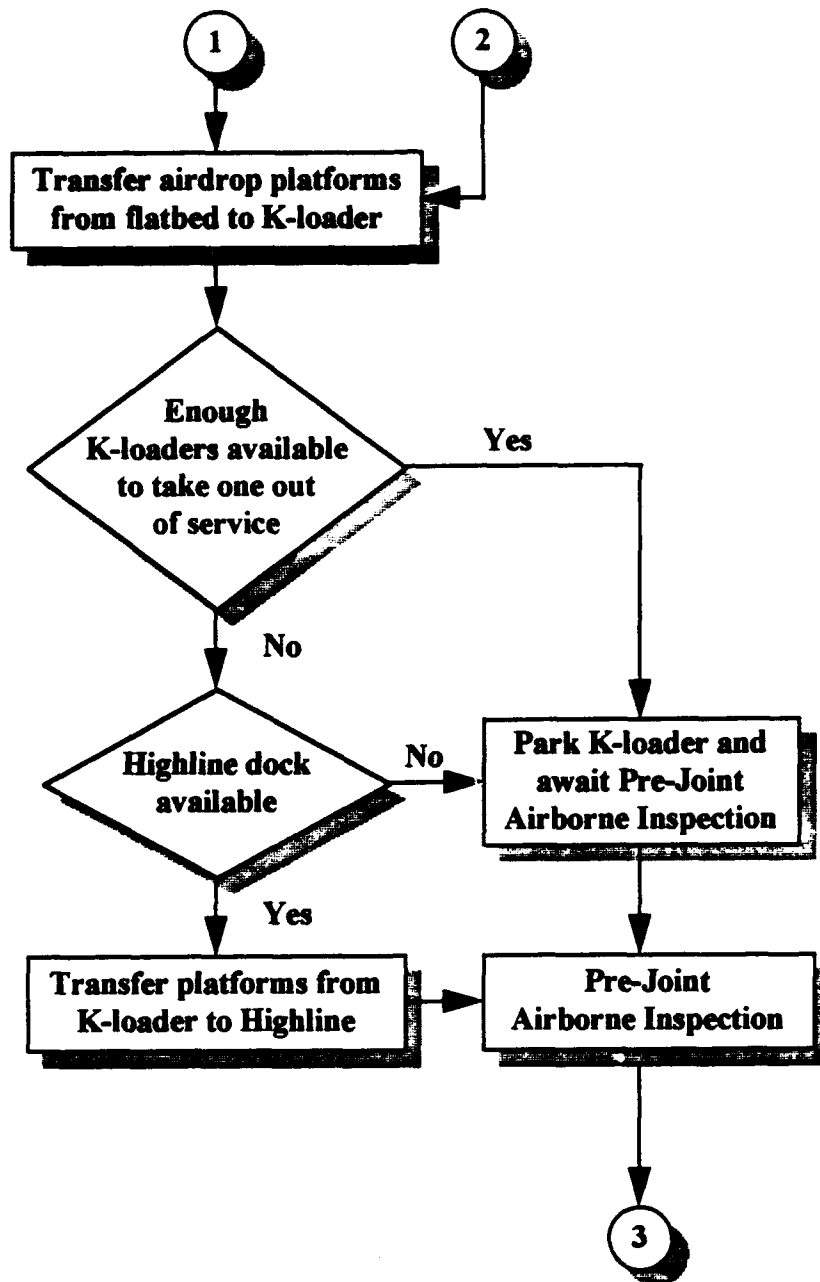
## Appendix B: Glossary of Acronyms

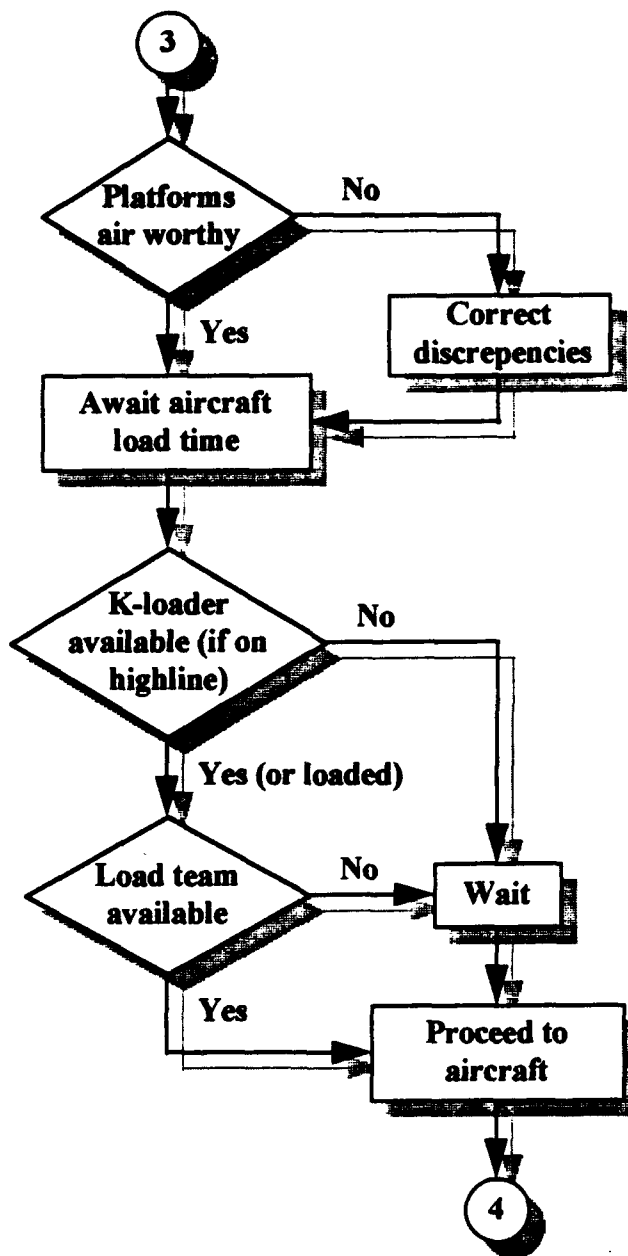
ACC	Air Combat Command
ACRDM	Air Cargo Reception and Distribution Model
ACT	Air Cargo Terminal
AFS	Airlift Flow System
ALM	Aircraft Loading Model
ALOW	Airland Operations Wing
AMC	Air Mobility Command
APOE	Aerial Port of Embarkation
APS	Aerial Port Squadron
APT	Air Passenger Terminal
AOR	Area of Responsibility
CCW	Integrated Operations Concept for Corps Element and Airland Operations Wing
DACG	Departure Airfield Control Group
DRB	Deployment Ready Brigade
EDRE	Emergency Deployment Readiness Exercise
FIREARM	Force Interactive Response Evaluator of Assembly, Replenishment, and Mobility
FORSCOM	Forces Command
GPSS/H	General Purpose Simulation System/H
IMO	Installation Mobility Officer
MCC	Mobility Control Center
MHE	Material Handling Equipment
ORI	Operational Readiness Inspection
PHA	Passenger Holding Area

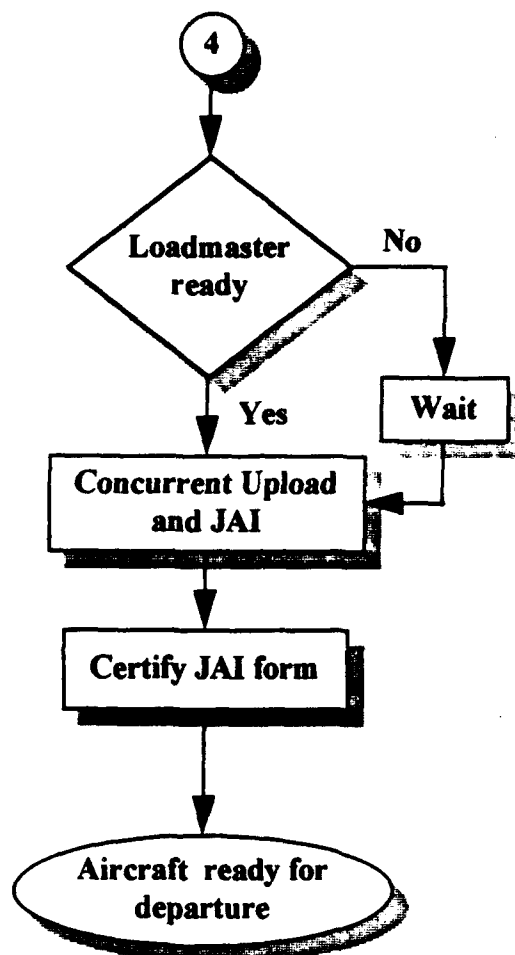
SIGMALOG	Strategic Mobility Scheduling Model
SMCT	Surface Movement and Commercial Terminal
SMOBSBOD	Simulation and Gaming Methods for Analysis of Logistics System
TCU	Transportation Control Unit
TRADOC	Training and Doctrine Command
TRANSCOM	Transportation Command

Appendix C: Communicative Deployment Model

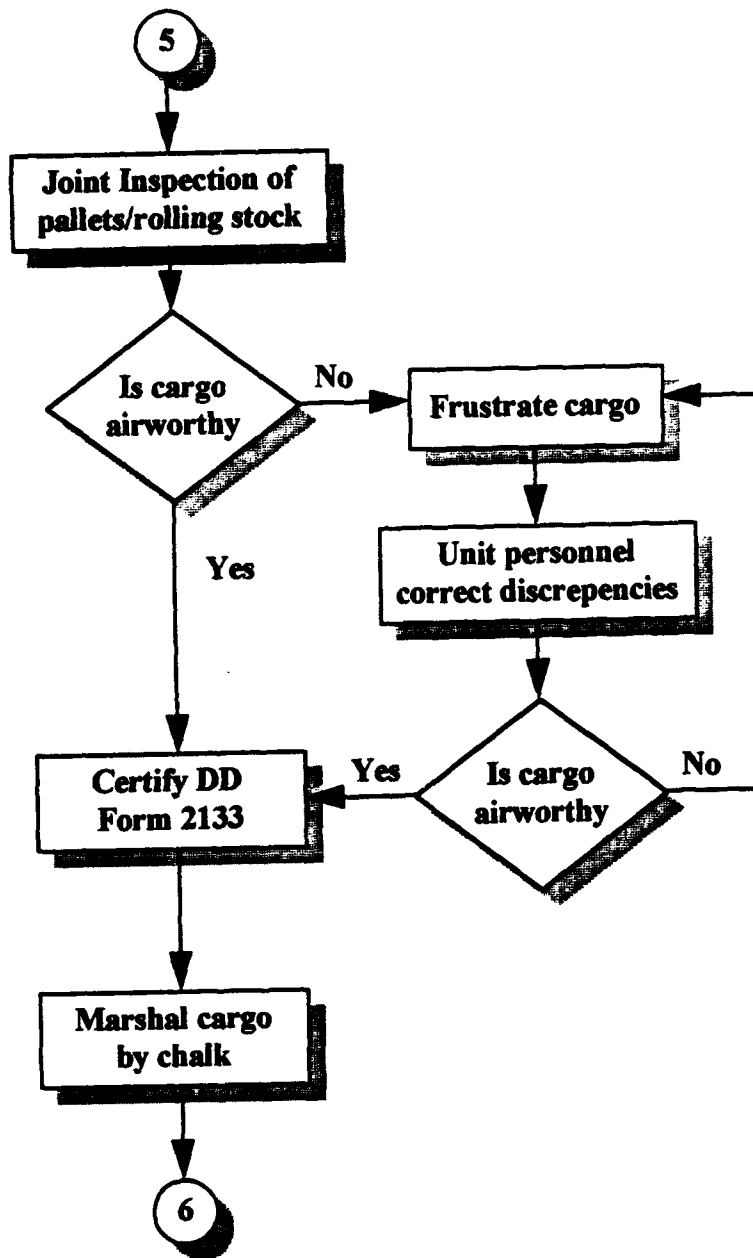


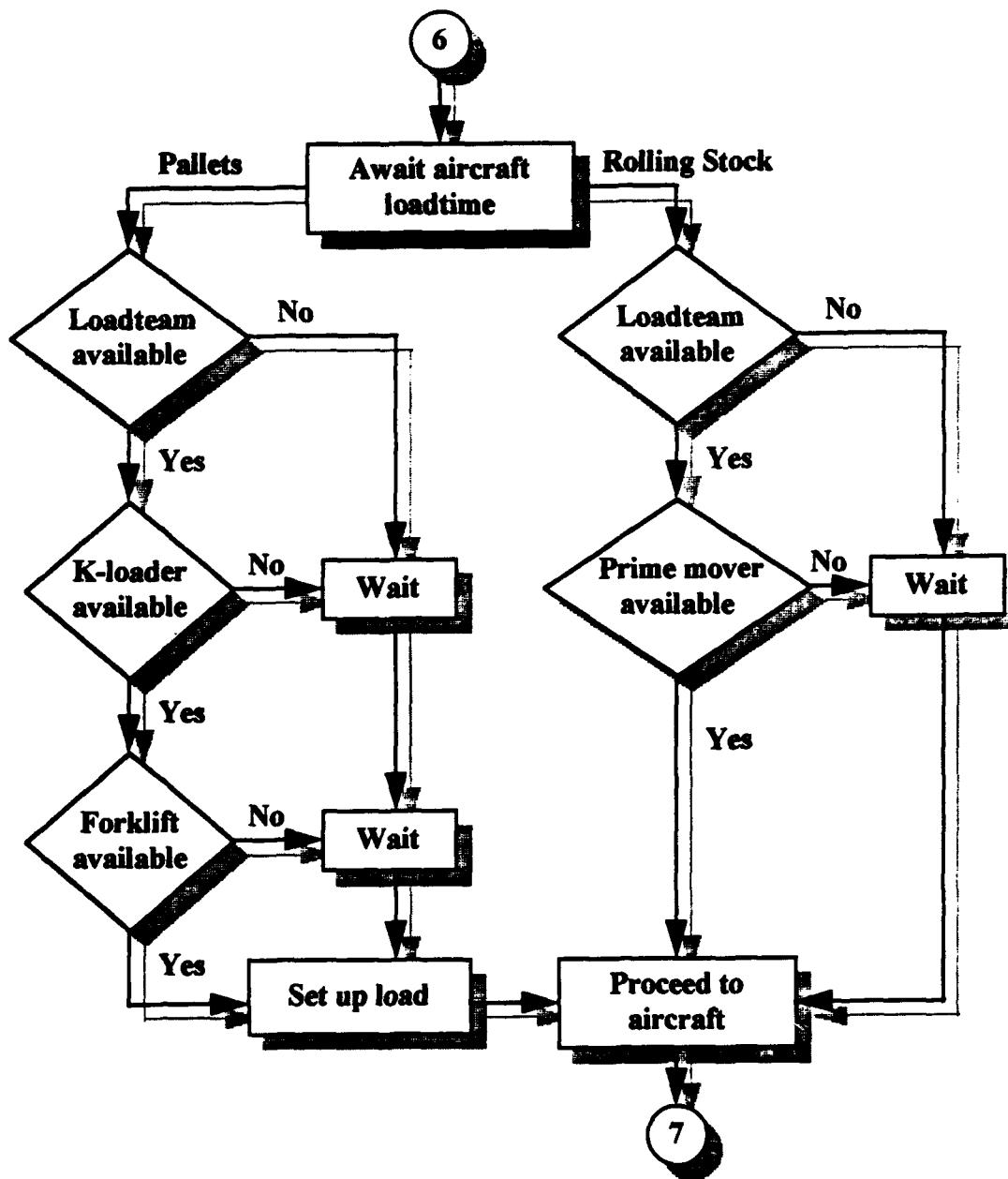


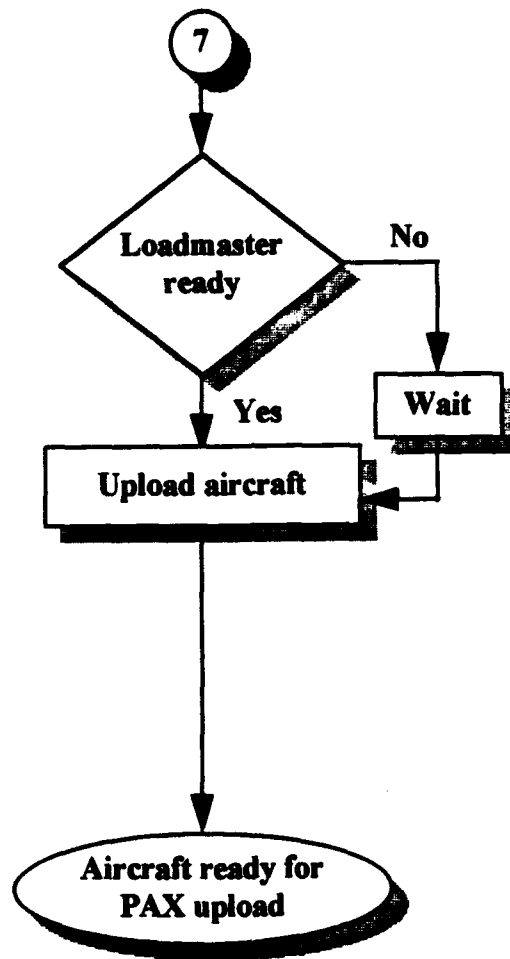


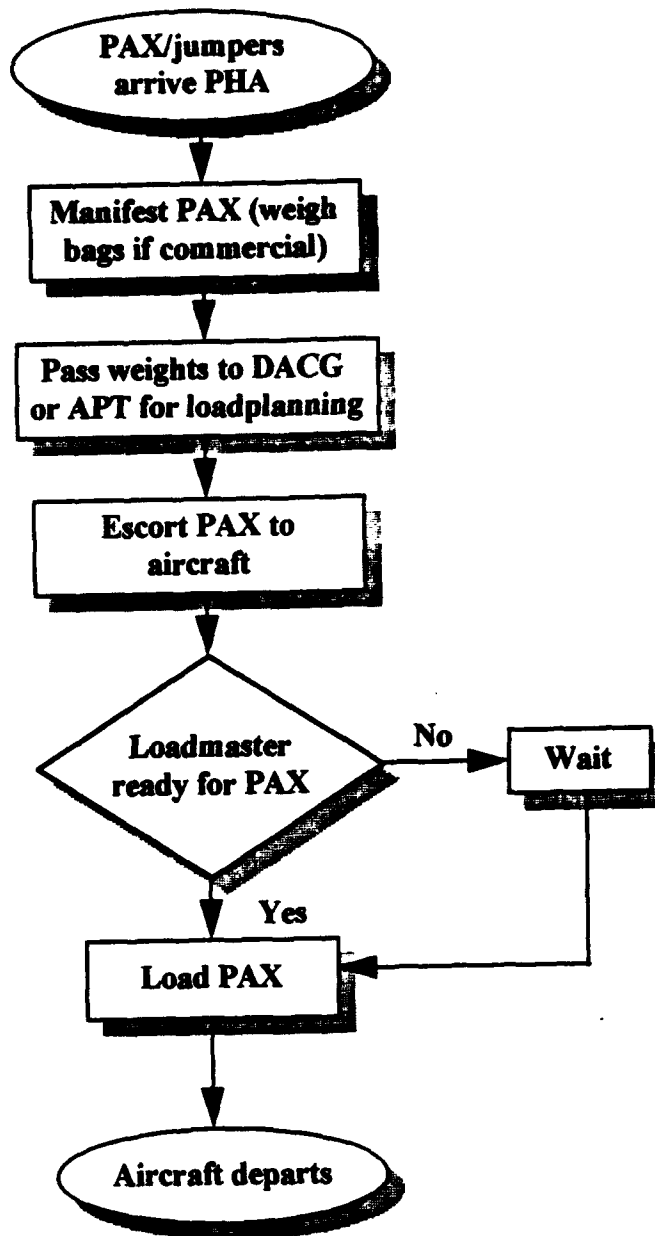












## Appendix D: GPSS/H-Coded Deployment Model

```
*
*                               DEPLOYMENT SIMULATION MODEL
*                               Capt Brad Prechtel
*                               Capt Mark Wingreen
*
*                               SIMULATE                               Base time unit: 1 minute
*                               REALLOCATE COM,100000                 Increase common storage
*                               REALLOCATE FAC,100                   Increase facilities to 100
*                               REALLOCATE STO,150                   Increase storages to 150
*****
*                               Compiler Directives                               *
*****
*
CHALK      EQU      1,PF      Equivalence statements to define
*                               X-act parameters
NOINC      EQU      2,PF
SERVICE   EQU      3,PF
ACTYPE     EQU      4,PF
INCNUMBER  EQU      5,PF
INCTYPE    EQU      6,PF
WEIGHT     EQU      7,PF
WTMIN      EQU      8,PF
WTMAX      EQU      9,PF
WTMODE     EQU      10,PF
LTMIN      EQU      11,PF
LTMAX      EQU      12,PF
LTMODE     EQU      13,PF
DEPTIME    EQU      14,PF
CGOTYPE    EQU      15,PF
MSN        EQU      16,PF
KTYPE      EQU      17,PF
NUMBRKLD   EQU      18,PF
FIRST      EQU      19,PF
NMBRLNKD   EQU      20,PF
SHUTYPE    EQU      21,PF
PALPOS     EQU      1,PL
FRUST      EQU      2,PL
*
*                               INTEGER      &I,&J      &I and &J are counts used to
*                               fill matrix PROCTYMS
*                               INTEGER      &KLODR40    Number of 40K-Loaders available to
*                               load increments
*                               INTEGER      &KLODR40S   Number of 40K-Loaders available to
*                               shuttle increments from scales to
*                               highlines
*                               INTEGER      &KLODR25    Number of 25K-Loaders available to
*                               load increments
*                               INTEGER      &KLODR25S   Number of 25K-Loaders available to
*                               shuttle increments from scales to
*                               highlines
```

*	INTEGER	&FL10	Number of 10K-Forklifts available to load increments
*	INTEGER	&FL10S	Number of 10K-Forklifts available to shuttle increments from scales to highlines
*	INTEGER	&DRIVERS	Number of equipment drivers available
*	INTEGER	&LDTEAMS	Number of load teams available
	INTEGER	&LDMAST	Number of loadmaster available
	INTEGER	&JOINT	Number of joint inspectors available
*	INTEGER	&SCALES	Number of scales available
*	INTEGER	&ORDERINC	A count to keep track of increment order
*	INTEGER	&FRSTINC	A count to determine the first increment on a piece of MHE
*	INTEGER	&TOTWGHT	A count of the total weight of increments on a K-loader
*	INTEGER	&LOADNUM	Numbers MHE loads
	INTEGER	&CHLK	A count of the current Chalk
	INTEGER	&INCSLNKD	A count of the increments linked on K-Loader
*	INTEGER	&ACC5	Number of C-5 parking spots on ramp
*	INTEGER	&ACC141	Number of C-141 parking spots on ramp
*	REAL	&TOTLNGTH	A count of the total length of increments on a K-Loader
*	REAL	&ARYARD	Number of pallet positions in Army marshaling yard
*	REAL	&AFYARD	Number of pallet positions in Air Force marshaling yard
*	REAL	&HILINES	Number of pallet positions available on highlines
*	LET	&CHLK=8	Set initial value of chalk counter to 1
*	LET	&ORDERINC=1	Set initial value of increment counter to 1

\*\*\*\*\*  
 \* Control Statements \*  
 \*\*\*\*\*  
 \*

PUTPIC  
 OPlease enter number of 40K-Loaders available for loading purposes  
 GETLIST &KLODR40  
 PUTPIC  
 OPlease enter number of 40K-Loaders available to shuttle incs from scale  
 GETLIST &KLODR40S  
 PUTPIC  
 OPlease enter number of 25K-Loaders available for loading purposes

```

        GETLIST      &KLODR25
        PUTPIC
OPlease enter number of 25K-Loaders available to shuttle incs from scale
        GETLIST      &KLODR25S
        PUTPIC
OPlease enter the number of 10K Forklifts available
        GETLIST      &FL10
        PUTPIC
OPlease enter number of 10K-Forklifts avail to shuttle incs from scale
        GETLIST      &FL10S
        PUTPIC
OPlease enter the number of MHE operators available
        GETLIST      &DRIVERS
        PUTPIC
OPlease enter the number of load teams available
        GETLIST      &LDTEAMS
        PUTPIC
OPlease enter the number of loadmasters available
        GETLIST      &LDMAST
        PUTPIC
OPlease enter the number of joint inspectors available
        GETLIST      &JOINT
        PUTPIC
OPlease enter the number of scales available
        GETLIST      &SCALES
        PUTPIC
OPlease enter number of pallet positions for the Army marshaling yard
        GETLIST      &ARYARD
        PUTPIC
OPlease enter the number of pallet positions for the AF marshaling yard
        GETLIST      &AFYARD
        PUTPIC
OPlease enter the number of pallet positions for the highline docks
        GETLIST      &HILINES
        PUTPIC
OPlease enter the number of C-5 parking spots available on ramp
        GETLIST      &ACC5
        PUTPIC
OPlease enter the number of C-141 parking spots available on ramp
        GETLIST      &ACC141
*
CHLKFILE FILEDEF      'INFOSIMP.TXT'      Trace file to read in chalk
*                                           number, number of increments in
*                                           chalk, departure time, branch
*                                           of service, and aircraft type
*                                           (THIS FILE CONTAINED ONLY
*                                           AIRDROP LOAD INFORMATION FOR
*                                           SENSITIVITY RUNS)
INCRFILE FILEDEF      'LDSIMP.TXT'      Trace file to read in increment
*                                           number, increment type, and
*                                           type of cargo (THIS FILE
*                                           CONTAINED ONLY AIRDROP LOAD

```

*			INFORMATION FOR SENSITIVITY
*			RUNS)
*	MATRXDAT FILEDEF	'PROCTYM.TXT'	Trace file containing the
*			inspection and loading times,
*			weight, pallet positions, and
*			frustration probabilities for
*			each type of increment
*	PROCTYMS MATRIX	ML,108,11	Definition statement telling
*			the number of rows and columns
*			in the increment data matrix
*	STORAGE	S(KLOAD40),&KLODR40	Define 40K-Loader storage
*			and capacity
*	STORAGE	S(KLOAD40S),&KLODR40S	Define 40K-Loader shuttle
*			storage and capacity
*	STORAGE	S(KLOAD25),&KLODR25	Define 25K-Loader storage
*			and capacity
*	STORAGE	S(KLOAD25S),&KLODR25S	Define 25K-Loader shuttle
*			storage and capacity
*	STORAGE	S(FL10K),&FL10	Define 10K forklift storage
*			and capacity
*	STORAGE	S(FL10KS),&FL10S	Define 10K forklift shuttle
*			storage and capacity
*	STORAGE	S(DRIVER),&DRIVERS	Define driver storage and
*			capacity
*	STORAGE	S(LDTEAM),&LDTEAMS	Define load team storage
*			and capacity
*	STORAGE	S(LDMASTER),&LDMAST	Define loadmaster storage
*			and capacity
*	STORAGE	S(JI),&JOINT	Define joint inspector
*			storage and capacity
*	STORAGE	S(SCALE),&SCALES	Define scale storage and
*			capacity
*	STORAGE	S(AMARSH),&ARYARD	Define Call Forward Area
*			storage and capacity
*	STORAGE	S(AFMARSH),&AFYARD	Define Air Force marshaling
*			yard storage and capacity
*	STORAGE	S(HILINE),&HILINES	Define highline storage and
*			capacity
*	STORAGE	S(ACFTC5),&ACC5	Define C-5 aircraft parking
*			storage and capacity
*	STORAGE	S(ACFTC141),&ACC141	Define C-141 aircraft
*			parking storage and
*			capacity
*	STORAGE	S(1),2	Define chalk storages and
*			capacity, these storages
*			will allow only one chalk
*			at a time at a particular
*			parking spot
	STORAGE	S(2),2	
	STORAGE	S(3),2	
	STORAGE	S(4),2	



STORAGE	S(5),2
STORAGE	S(6),2
STORAGE	S(7),2
STORAGE	S(8),2
STORAGE	S(9),2
STORAGE	S(10),2
STORAGE	S(11),2
STORAGE	S(12),2
STORAGE	S(13),2
STORAGE	S(14),2
STORAGE	S(15),2
STORAGE	S(16),2
STORAGE	S(17),2
STORAGE	S(18),2
STORAGE	S(19),2
STORAGE	S(20),2
STORAGE	S(21),2
STORAGE	S(22),2
STORAGE	S(23),2
STORAGE	S(24),2
STORAGE	S(25),2
STORAGE	S(26),2
STORAGE	S(27),2
STORAGE	S(28),2
STORAGE	S(29),2
STORAGE	S(30),2
STORAGE	S(31),2
STORAGE	S(32),2
STORAGE	S(33),2
STORAGE	S(34),2
STORAGE	S(35),2
STORAGE	S(36),2
STORAGE	S(37),2
STORAGE	S(38),2
STORAGE	S(39),2
STORAGE	S(40),2
STORAGE	S(41),2
STORAGE	S(42),2
STORAGE	S(43),2
STORAGE	S(44),2
STORAGE	S(45),2
STORAGE	S(46),2
STORAGE	S(47),2
STORAGE	S(48),2
STORAGE	S(49),2
STORAGE	S(50),2
STORAGE	S(51),2
STORAGE	S(52),2
STORAGE	S(53),2
STORAGE	S(54),2
STORAGE	S(55),2
STORAGE	S(56),2

STORAGE	S(57),2
STORAGE	S(58),2
STORAGE	S(59),2
STORAGE	S(60),2
STORAGE	S(61),2
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STORAGE	S(63),2
STORAGE	S(64),2
STORAGE	S(65),2
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STORAGE	S(72),2
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STORAGE	S(75),2
STORAGE	S(76),2
STORAGE	S(77),2
STORAGE	S(78),2
STORAGE	S(79),2
STORAGE	S(80),2
STORAGE	S(81),2
STORAGE	S(82),2
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STORAGE	S(86),2
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STORAGE	S(96),2
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STORAGE	S(101),2
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STORAGE	S(103),2
STORAGE	S(104),2
STORAGE	S(105),2
STORAGE	S(106),2
STORAGE	S(107),2
STORAGE	S(108),2

STORAGE	S(109),2	
STORAGE	S(110),2	
STORAGE	S(111),2	
STORAGE	S(112),2	
STORAGE	S(113),2	
STORAGE	S(114),2	
STORAGE	S(115),2	
STORAGE	S(116),2	
STORAGE	S(117),2	
STORAGE	S(118),2	
STORAGE	S(119),2	
STORAGE	S(120),2	
STORAGE	S(121),2	
STORAGE	S(122),2	
STORAGE	S(123),2	
STORAGE	S(124),2	
STORAGE	S(125),2	
STORAGE	S(126),2	
STORAGE	S(127),2	
STORAGE	S(128),2	
STORAGE	S(129),2	
STORAGE	S(130),2	
STORAGE	S(131),2	
STORAGE	S(132),2	
STORAGE	S(133),2	
STORAGE	S(134),2	
STORAGE	S(135),2	
* FULL25K	BVARIABLE	&TOTWGHT'LE'25000*_ &TOTLNGTH'LE'3*SNF(KLOAD25)
* FULL25KS	BVARIABLE	PF(WEIGHT)'LE'25000*_ PL(PALPOS)'LE'3*_ SNF(KLOAD25S)
* FULL40K	BVARIABLE	&TOTWGHT'LE'40000*_ &TOTLNGTH'LE'5
* FULL10K	BVARIABLE	&TOTWGHT'LE'10000*_ &TOTLNGTH'LE'1.2*SNF(FL10K)
* FULL10KS	BVARIABLE	PF(WEIGHT)'LE'10000*_ PL(PALPOS)'LE'1.2*_ SNF(FL10KS)
* CHOOSE	BVARIABLE	PF(WEIGHT)<=25000*_

Boolean variable to  
determine if 25K-  
Loader is full and if  
one is available

Boolean variable to  
determine if shuttle  
25K-Loader is  
available and if  
increment will fit

Boolean variable to  
determine if 40K-  
Loader is full or not

Boolean variable to  
determine if  
increment will fit on  
a 10K-Forklift and if  
one is available

Boolean variable to  
determine if  
increment will fit  
on a shuttle 10K-  
Forklift and if one  
is available

Boolean variable to



	SSIGN	PF(INCTYPE),5),PF	time from matrix value
		WTMODE,ML(PROCTYMS,PF(INCTYPE),6),PF	Assign mode weighing
	ASSIGN	LTMIN,ML(PROCTYMS,PF(INCTYPE),7),PF	time from matrix value
			Assign minimum loading
	ASSIGN	LTMAX,ML(PROCTYMS,PF(INCTYPE),8),PF	time from matrix value
			Assign maximum loading
	ASSIGN	LTMODE,ML(PROCTYMS,PF(INCTYPE),9),PF	time from matrix value
			Assign mode loading time
	ASSIGN	CGOTYPE,ML(PROCTYMS,PF(INCTYPE),10),PF	from matrix value
			Assign cargo or load type
			from matrix value
			(1=pallet, 2=rolling
			stock, 3=airdrop,
			4=passengers)
	ASSIGN	FRUST,ML(PROCTYMS,PF(INCTYPE),11),PL	Assign frustration proba-
			bility from matrix value
	TEST E	PF(SERVICE),300,WAA	Army loads fall through,
			Air Force loads sent to
			Air Force model segment
	TEST NE	PF(CGOTYPE),4,GOOD	Passenger loads are sent
			to GATHER statement for
			further movement to Army
			passenger processing
			model segment
	TEST E	PF(CGOTYPE),3,AIRLAND	Airdrop loads fall
			through, airland loads
			sent to another segment
*****			
* Army Airdrop Highline and K-Loader Selection Model Segment *			
*****			
	TEST E	BV(FULL10KS),1,SHU25K	If it will fit on a
			10K-Forklift, then fall
			through
	ENTER	FL10KS	Get shuttle 10K-Forklift
	ASSIGN	SHUTYPE,10,PF	Mark increment as going
			on a shuttle 10K-Forklift
	TRANSFER	,SCALETYM	
SHU25K	TEST E	BV(FULL25KS),1,SHU40K	If it will fit on a
			25K-Loader, then fall
			through
	ENTER	KLOAD25S	Get a shuttle 25K-Loader
	ASSIGN	SHUTYPE,25,PF	Mark it as going on a
			shuttle 25K-Loader
	TRANSFER	,SCALETYM	
SHU40K	ENTER	KLOAD40S	Get a shuttle 40K-Loader
	ASSIGN	SHUTYPE,40,PF	Mark it as going on a
			shuttle 40K-Loader
SCALETYM	ENTER	DRIVER	Get a driver

	ENTER	SCALE	Seize the scale
	ENTER	LDMASTER	Get a loadmaster
	ADVANCE	RVTRI(2,PF(WTMIN), PF(WTMODE),PF(WTMAX))	Weigh, JAI, and place increment on MHE
	LEAVE	LDMASTER	Release loadmaster
	LEAVE	SCALE	Release scale
	TRANSFER	.(1000-PL(FRUST)*1000),,OK1	Proportion of increments are frustrated
*			
*			
	LEAVE	DRIVER	Release driver while increment discrepancy is corrected
*			
	ADVANCE	10,5	Correct discrepancies
	ENTER	DRIVER	Get a driver
OK1	ADVANCE	4,1	Time to move from scales to highlines or staging area
*			
*			
	TEST E	PF(SHUTYPE),10,REL25KS	If on a shuttle 10K-Fork lift, then send through
*			
	ENTER	HILINE,PL(PALPOS)+.55	Take up highline space
	LEAVE	DRIVER	Release MHE driver
	LEAVE	FL10KS	Release shuttle 10K- Forklift
*			
	TRANSFER	,HIGATHER	
REL25KS	TEST E	PF(SHUTYPE),25,REL40KS	If on a shuttle 25K- Loader, then send through
*			
	ENTER	HILINE,PL(PALPOS)+.55	Take up highline space
	LEAVE	DRIVER	Release MHE driver
	LEAVE	KLOAD25S	Release shuttle 25K-Ldr
	TRANSFER	,HIGATHER	
REL40KS	ENTER	HILINE,PL(PALPOS)+.55	Take up highline space
	LEAVE	DRIVER	Release MHE driver
	LEAVE	KLOAD40S	Release shuttle 40K-Ldr
HIGATHER	PRIORITY	1	Increase priority to 1
	GATHER	PF(NOINC)	Wait until entire chalk is on highlines
*			
	TEST NE	PF(INCNUMBR),1,MHESEL	Test if its the first increment for chalk
*			
	LINK	CHALKNO,(INCNUMBR)PF	If not, link on user chain in increasing increment order
*			
*			
MHESEL	PRIORITY	PR,BUFFER	Delay lead increment
	TEST LE	AC1,PF(DEPTIME)-175,SET	Determine if it is time to remove piece from highline and transfer to a K-Loader
*			
*			
*			
	ADVANCE	PF(DEPTIME)-175-AC1	If not, wait until load set-up time
*			
SET	GATE LR	NEXTCHLK	Only let one chalk into the MHE selection segment at one time
*			
*			
	LOGIC S	NEXTCHLK	Set switch for above gate

	UNLINK E	CHALKNO,MHESEL2,ALL,_(CHALK)PF,PF(CHALK)	Unlink all increments from the chalk, will come off in increasing increment number order
*			
*	MHESEL2	TEST E	BV(MHEAVAIL),1
*			Ensures adequate MHE is available before pulling increments off the highline
*		BLET	&ORDERINC=&ORDERINC+1
*			Increase increment count by 1
*		TEST E	PF(INCNUMBR),1,SAMECHLK
*			If it's the first increment from a new chalk,
*			then fall through, if not send to SAMECHALK
*		TRANSFER	,GONEWKLD
*			
*	The following segment sends any increment small enough to fit on a		
*	25K-Loader to seize one as long as one is available. Increments		
*	requiring a 40K-Loader are sent to get one, the GOTO40K GATE ensures		
*	succeeding increments will follow. The FULL GATE is set to allow		
*	increments loading on the last K-Loader to proceed.		
*			
*	SAMECHLK	GATE LR	GOTO40K,FILL40K
*			If logic switch is reset, send increment through
*		TEST E	BV(CHOOSE),0,FILL25K
*			If it won't fit on 25K-Loader, send through
*		TEST NE	PF(INCNUMBR),1,PROCEED
*			If its the first increment of chalk, send through
*			
*		LOGIC S	FULL
	PROCEED	LOGIC S	GOTO40K
		TRANSFER	,FILL40K
*			Set logic switch
*			
*	FILL25K	BLET	&FRSTINC=&FRSTINC+1
*			Increase K-Loader increment counter by 1
*		BLET	&TOTWGHT=&TOTWGHT+_PF(WEIGHT)
			Add increment's weight to total weight
*		BLET	&TOTLNGTH=&TOTLNGTH+_PL(PALPOS)
			Add increment's length to total length
*		TEST NE	&FRSTINC,1,GET25K
*			If its not the first increment on K-Loader, send through
*			
*		TEST E	BV(FULL25K),1,GONEWKLD
*			If it will fit on a 25K-Loader, then send through
*		BLET	&INCSLNKD=&INCSLNKD+1
*			Increase counter of increments linked by 1
*		ASSIGN	KTYPE,25,PF
*			Mark increment as going on a 25K-Loader
*		ASSIGN	NUMBRKLD,&LOADNUM,PF
*			Assign K-Loader number for unlinking purposes
*		PRIORITY	2
			Increase priority to 2

	TEST E	PF(NOINC),PF(INCNUMBER),_	If the last increment in
		WAIT25K	chalk, then send through
	LOGIC S	FULL	Set logic switch
	PRIORITY	PR,BUFFER	Delay increment
	BLET	&TOTWGHT=0	Reset weight ampervari-
*			able to 0
	BLET	&TOTLNGTH=0	Reset length ampervari-
*			able to 0
	BLET	&FRSTINC=0	Reset K-Loader increment
*			counter to 0
	LOGIC R	GOTO40K	Reset logic switch
WAIT25K	GATE LS	FULL	If logic switch is set,
*			then send through
	ASSIGN	NMBRLNKD,&INCSLNKD,PF	Assign increments linked
*			count number
	TEST E	PF(NOINC),PF(INCNUMBER),_	If its the last inc,
		NEXT25	fall through
	BLET	&ORDERINC=1	Set increment order
*			counter to 1
	BLET	&INCSLNKD=0	Reset increments linked
*			counter to 0
	LOGIC R	FULL	Reset logic switch
	LEAVE	HILINE,PL(PALPOS)+.55	Release highline space
	LOGIC R	NEXTCHLK	Reset gate to let next
*			chalk into MHE selection
*			segment
	PRIORITY	3	Increase priority to 3
NEXT25	LINK	NUMBERK,FIFO	Put on K-Loader user
*			chain
	GET25K	TEST NE	PF(NOINC),PF(INCNUMBER),_
			GONEWKLD
			If not last increment,
			then fall through
	LOGIC R	FULL	Reset logic switch
	BLET	&LOADNUM=&LOADNUM+1	Increase K-Loader counter
*			by 1
	ENTER	KLOAD25	Need a 25K-Loader
	ASSIGN	KTYPE,25,PF	Mark increment as going
*			on a 25K-Loader
	ASSIGN	NUMBRKLD,&LOADNUM,PF	Assign K-Loader number
*			for unlinking purposes
LEAD25	PRIORITY	2	Increase priority to 2
	GATE LS	FULL	Lets increments through
*			when logic switch is set
	TRANSFER	,LASTSET	
*			
	FILL40K	GATE LR	GOINKLDR
*			Lets increments through
			when logic switch reset
	BLET	&FRSTINC=&FRSTINC+1	Counter for number of
*			increments on K-Loader
	BLET	&TOTWGHT=&TOTWGHT+_	Add increment's weight
		PF(WGHT)	to total weight



	BLET	&TOTLNGTH=&TOTLNGTH_ PL(PALPOS)	Add increment's length to total length
	TEST NE	&FRSTINC,1,GET40K	If its not the first increment on K-Loader, then fall through.
*			
*	TEST E	BV(FULL40K),1,GONEWKLD	If it won't fit on same 40K-Loader, try new MHE
*	BLET	&INCSLNKD=&INCSLNKD+1	Increase increments linked counter by 1
*	ASSIGN	KTYPE,40,PF	Mark increment as going on a 40K-Loader
*	ASSIGN	NUMBRKLD,&LOADNUM,PF	Assign K-Loader number for unlinking purposes
*	PRIORITY	2	Increase priority to 2
	TEST E	PF(NOINC),PF(INCNUMBER),_ WAIT40K	If its last increment on chalk, send through
	LOGIC S	GOINKLDR	Set logic switch
	LOGIC S	FULL	Set logic switch
	PRIORITY	PR,BUFFER	Delay increment
	BLET	&TOTWGHT=0	Reset weight ampervari- able to 0
*			
*	BLET	&TOTLNGTH=0	Reset length ampervari- able to 0
*			
*	BLET	&FRSTINC=0	Reset K-Loader increment counter to 0
	LOGIC R	GOTO40K	Reset logic switch
	LOGIC R	GOINKLDR	Reset logic switch
WAIT40K	GATE LS	FULL	Let incs through when logic switch is set
*			
	ASSIGN	NMBRLNKD,&INCSLNKD,PF	Assign inc count number
	TEST E	PF(NOINC),PF(INCNUMBER),_ NEXT40	If its the last inc on K-Loader send through
	BLET	&ORDERINC=1	Reset increment order counter to 1
*			
*	BLET	&INCSLNKD=0	Reset increments linked counter to 0
*			
	LOGIC R	FULL	Reset logic switch
	LOGIC R	GOINMHE	Reset logic switch
	LEAVE	HILINE,PL(PALPOS)+.55	Release highline space
	LOGIC R	NEXTCHLK	Reset logic switch so next chalk can enter MHE selection segment
*			
*			
	PRIORITY	3	Increase priority to 3
NEXT40	LINK	NUMBERK,FIFO	Place on K-Loader user chain
*			
GET40K	TEST NE	PF(NOINC),PF(INCNUMBER),_ GONEWKLD	If its not the last increment,send through
	LOGIC R	FULL	Reset logic switch
	BLET	&LOADNUM=&LOADNUM+1	Increase K-Loader counter by one
*			
	ENTER	KLOAD40	Get 40K-Loader
	ASSIGN	KTYPE,40,PF	Mark increment as going

*			on a 40K-Loader
*	ASSIGN	NUMBRKLD,&LOADNUM,PF	Assign K-Loader number
			for unlinking purposes
*	PRIORITY	2	Increase priority to 2
	GATE LS	FULL	Let increments through
*			when logic switch is set
*	TRANSFER	,LASTSET	
GONEWKLD	PRIORITY	2	Increase priority to 2
	LOGIC S	GOINKLDR	Set logic switch
	LOGIC S	FULL	Set logic switch
	PRIORITY	PR,BUFFER	Delay increment
	BLET	&INCSLNKD=0	Reset incs linked to 0
	BLET	&TOTWGHT=0	Reset weight ampervari-
*			able to 0
	BLET	&TOTLNGTH=0	Reset length ampervari-
*			able to 0
	BLET	&FRSTINC=0	Reset K-Loader increment
*			counter to 0
	LOGIC R	GOTO40K	Reset logic switch
	LOGIC R	FULL	Reset logic switch
	LOGIC R	GOINKLDR	Reset logic switch
	TEST E	PF(NOINC),PF(INCNUMBER),_	If its only increment or
		SAMECHLK	last increment on chalk,
*			then fall through
	LOGIC R	NEXTCHLK	Reset logic switch so
*			next chalk can enter MHE
*			selection segment
	BLET	&ORDERINC=1	Reset increment order
*			counter to one
	BLET	&LOADNUM=&LOADNUM+1	Increase K-loader counter
*			by 1
	BLET	&TOTWGHT=&TOTWGHT+_	Add incs's weight to
		PF(WGHT)	total weight
	BLET	&TOTLNGTH=&TOTLNGTH+_	Add inc's length to total
		PL(PALPOS)	length
	TEST E	BV(FULL10K),1,TRY25K	Test to see if it will
		PL(PALPOS)	fit on a 10K forklift
	ENTER	FL10K	Enter forklift storage
	ASSIGN	KTYPE,10,PF	Mark increment as going
*			on a 10K-Forklift
	TRANSFER	,LASTSET	
TRY25K	TEST E	BV(FULL25K),1,TRY40K	Test if it will fit on a
*			25K-Loader
	ENTER	KLOAD25	Get 25K-Loader
	ASSIGN	KTYPE,25,PF	Mark increment as going
*			on a 25K-Loader
	ASSIGN	NUMBRKLD,&LOADNUM,PF	Assign K-Loader number
*			for unlinking purposes
	TRANSFER	,LASTSET	
TRY40K	ENTER	KLOAD40	Get 40K-Loader
	ASSIGN	KTYPE,40,PF	Mark increment as going

*			on a 40K-Loader
*	ASSIGN	NUMBRKLD, &LOADNUM, PF	Assign K-Loader number
*	LASTSET	ASSIGN	for unlinking purposes
		NMBRLNKD, &INCSLNKD, PF	Assign increment linked
			count number
*	BLET	&TOTWGHT=0	Reset weight ampervari-
			able to 0
*	BLET	&TOTLNGTH=0	Reset length ampervari-
			able to 0
*	BLET	&FRSTINC=0	Reset K-Loader increment
			counter to 0
*	ASSIGN	FIRST, 1, PF	Assign parameter to mark
*			increment as the first on
*			the MHE
*	PRIORITY	PR, BUFFER	Hold lead increment until
			others can be linked
	BLET	&INCSLNKD=0	Reset linked count to 0
	PRIORITY	3	Increase priority to 3
	ENTER	DRIVER	Get an MHE driver
	ADVANCE	5, 1	Push from highline to
*			K-Loader
	LEAVE	HILINE, PL(PALPOS)+.55	Release highline space
	TEST LE	AC1, PF(DEPTIME)-140, _	If its not time to load
		LDTIME	increment, fall through
	LEAVE	DRIVER	Release MHE driver
	ADVANCE	PF(DEPTIME)-140-AC1	Wait until load time
	ENTER	DRIVER	Seize MHE driver
	TEST NE	PF(NMBRLNKD), 0, HOLD	If increment has others
*			linked with it, then it
*			falls through
	LDTIME	BOTH, LINE5, LINE6	Send to open path
	LINE5	SEIZE	Seize unlinking path
*		GETINCS5	segment
	TRYAGAN5	UNLINK E	Remove increments from
		NUMBERK, UPPRIORS5, ALL, _	K-Loader user chain
		(NUMBRKLD) PF, PF(NUMBRKLD)	Increase priority to 6
	UPPRIORS5	PRIORITY	If its the lead increment
		TEST E	on a K-Loader, then fall
*		PF(FIRST), 1, GOWAIT5	through
*			Delay increment
	PRIORITY	PR, BUFFER	If all linked
	TEST NE	W(GOWAIT5), PF(NMBRLNKD), _	increments are waiting
*		GOWAIT5	in block GOWAIT5, then
*			send lead increment there
	ADVANCE	1	Wait one minute before
*			sending to unlink block
	TRANSFER	, TRYAGAN5	Send lead increment to
*			unlink block
	GOWAIT5	GATHER	Hold until all increments
*		PF(NMBRLNKD)+1	for K-Loader are ready
*			Send lead increment
*	TEST E	PF(FIRST), 1, HOLD	through

*	RELEASE	GETINCS5	Release increment
*			unlinking path for next
*	TRANSFER	,HOLD	K-Loader
*			Send to wait for entire
LINE6	SEIZE	GETINCS6	chalk
*			Seize unlinking path
TRYAGAN6	UNLINK E	NUMBERK,UPPRIOR6,ALL, _	segment
		(NUMBERKLD)PF,PF(NUMBERKLD)	Remove increments from
UPPRIOR6	PRIORITY	6	K-Loader user chain
	TEST E	PF(FIRST),1,GOWAIT6	Increase priority to 6
*			If its the lead increment
	PRIORITY	PR,BUFFER	then send through
	TEST NE	W(GOWAIT6),PF(NMBRLNKD), _	Delay lead increment
*		GOWAIT6	If all linked
*			increments are waiting
*			in block GOWAIT6, then
	ADVANCE	1	send lead increment there
*			Wait one minute before
	TRANSFER	,TRYAGAN6	sending to unlink block
*			Send lead increment to
GOWAIT6	GATHER	PF(NMBRLNKD)+1	unlink block
*			Hold until all increments
	TEST E	PF(FIRST),1,HOLD	for K-Loader are ready
*			Send lead increment
	RELEASE	GETINCS6	through
*			Release increment
*			unlinking path for next
HOLD	GATHER	PF(NOINC)	K-Loader
*			Hold until all increments
	TEST E	PF(FIRST),0,KLINK	are ready for upload
*			If not the lead
	PRIORITY	8	increment, send through
	LINK	NUMBERK,FIFO	Increase priority to 8
*			Put back on K-Loader
KLINK	PRIORITY	7	user chain
	TEST NE	PF(INCNUMBR),1,SELACFT	Increase priority to 7
*			Send first increment of
*			chalk to aircraft, rest
	LINK	CHALKNO,FIFO	fall through
SELACFT	ADVANCE	8,2	Put on chalk user chain
*			Time to drive MHE to
	TRANSFER	,LOADC141	aircraft parking spot
*			Transfer to the C-141
*			aircraft loading model
*			segment
*****			
*	Army Airland Load Processing Model Segment		
*****			
AIRLAND	PRIORITY	5	Increase priority so
*			that all cargo is
*			loaded before PAX

	ENTER	SCALE	Seize one of the roll-on scales
*			
	ENTER	JI	Seize one of the joint inspectors
*			
	ADVANCE	RVTRI(4,PF(WTMIN),PF(WTMODE),PF(WTMAX))	Weigh and inspect cargo
	LEAVE	SCALE	Release Roll-on scale
	LEAVE	JI	Release joint inspector
	TRANSFER	.(1000-PL(FRUST)*1000),,GOOD	Proportion are frustrated
	ADVANCE	25,20	Time to correct problems
GOOD	ADVANCE	3	Move to chalk assembly area
*			
	ENTER	AMARSH,PL(PALPOS)	Go in chalk assembly area
	GATHER	PF(NOINC)	Hold until all increments are present
*			
	TEST LE	AC1,PF(DEPTIME)-210,READY	Determine if its load set-up time
	ADVANCE	PF(DEPTIME)-210-AC1	If not, wait until load set-up time
*			
READY	TEST NE	PF(CGOTYPE),4,APAX	Send passenger increments to Army passenger processing segment
*			
*			
	TEST E	PF(CGOTYPE),1,RS	If pallet, fall through
*			
	TERMINATE	0	DUMMY TERMINATE BLOCK
*			THE MHE SELECTION SEGMENT
*			NEEDS TO BE ADDED
*			
*****			
*	Army Passenger Processing Model Segment		*
*****			
*			
APAX	TERMINATE	0	DUMMY TERMINATE BLOCK
*			THIS SECTION NEEDS TO
*			BE COMPLETED
*			
*****			
*	Air Force Load Processing Model Segment		*
*****			
*			
WAA	TEST NE	PF(CGOTYPE),4,WAIT	Send passenger loads to GATHER statement for further movement to passenger processing model segment
*			
*			
*			
	PRIORITY	5	Increase priority so that all cargo is loaded before passengers
*			
*			
	TEST E	PF(CGOTYPE),1,RS	If palletized, fall through
*			
	ENTER	DRIVER	Seize forklift driver

	ENTER	FL10K	Enter forklift storage
	ENTER	JI	Seize joint inspector
	ADVANCE	RVTRI(5,PF(WTMIN), PF(WTMODE),PF(WTMAX))	Inspection time
	LEAVE	JI	Release joint inspector
	TRANSFER	.(1000-PL(FRUST)*1000) ,,FINE	Proportion are frustrated
FINE	ADVANCE	25,20	Time to correct problems
*	ADVANCE	2	Move to chalk assembly area
*	ENTER	AFMARSH,PL(PALPOS)	Takes up space in Air Force chalk assembly area
	LEAVE	FL10K	Release 10K-Forklift
	LEAVE	DRIVER	Release forklift driver
	TRANSFER	,WAIT	Send increment to wait for other increments
RS	ENTER	JI	Seize joint inspector
	ADVANCE	RVTRI(6,PF(WTMIN), PF(WTMODE),PF(WTMAX))	Inspection time
	LEAVE	JI	Release joint inspector
	TRANSFER	.(1000-PL(FRUST)*1000) ,,WAIT	Proportion are frustrated
	ADVANCE	25,20	Time to correct problems
WAIT	GATHER	PF(NOINC)	Hold until all increments are present
*	TEST E	PF(ACTYPE),5,ACFT141	If increment goes on a C-5, it falls through, if not goes to C-141
*	TEST LE	AC1,PF(DEPTIME)-210,SETUP	Determine if its load set-up time, if not..
*	ADVANCE	PF(DEPTIME)-210-AC1	Wait until load set-up time
*	TRANSFER	,SETUP	Send to test for cargo type
ACFT141	TEST LE	AC1,PF(DEPTIME)-150,SETUP	Determine if its load set-up time, if not..
*	ADVANCE	PF(DEPTIME)-150-AC1	Wait until load set-up time
SETUP	TEST NE	PF(CGOTYPE),4,AFPAX	Send passenger loads to Air Force passenger processing model segment
*	TEST E	PF(CGOTYPE),1,ROLLS	If pallet or floor load, fall through
ROLLS	TERMINATE	0	DUMMY TERMINATE BLOCK THE MHE SELECTION SEGMENT NEEDS TO BE ADDED

\*\*\*\*\*  
 \*           Air Force Passenger Loading Model Segment           \*  
 \*\*\*\*\*  
 \*

* AFFAX		TERMINATE 0	DUMMY TERMINATE BLOCK
* *			THIS SECTION NEEDS TO BE
* *			COMPLETED
*****			
* C-141 Aircraft Loading Model Segment			*
*****			
LOADC141	ENTER	ACFTC141	If a C-141 parking spot
			is available, go through
	TEST NE	PF(CGOTYPE),4,PAX141	If a passenger load, send
			to passenger loading
			segment
	ENTER	LDTEAM	Capture a load team
	UNLINK E	CHALKNO,CHKPAX,ALL, _	Unlink the rest of the
		(CHALK)PF,PF(CHALK)	K-Loaders or rolling
			stock on chalk
CHKPAX	TEST NE	PF(CGOTYPE),4,PAX141	If passenger load, send
			to passenger loading
			segment
	ENTER	PF(CHALK),2	Seize the aircraft
	PRIORITY	8	Increase priority to 8
	ADVANCE	5,2	Position behind aircraft
	ADVANCE	RVTRI(7,PF(LTMIN), _	Load increment on C-141
		PF(LTMODE),PF(LTMAX))	
	UNLINK E	NUMBERK,MHECHAIN,ALL, _	Release other increments
		(NUMBERKLD)PF,PF(NUMBERKLD)	from user chain, if any
	PRIORITY	PR,BUFFER	Delay increment
MHECHAIN	TEST E	PF(FIRST),1,UPLOAD1	If its the lead increment
			send through
	LEAVE	PF(CHALK),2	Release C-141 for next
			increment
	TRANSFER	,MOVE	Move to MHE release
UPLOAD1	ENTER	PF(CHALK),2	Seize the aircraft
	ADVANCE	RVTRI(8,PF(LTMIN), _	Load increment on C-141
		PF(LTMODE),PF(LTMAX))	
	LEAVE	PF(CHALK),2	Release C-141 for next
			increment
	TRANSFER	,MOVE	Move to MHE release test
PAX141	ENTER	PF(CHALK),2	Seize the aircraft
	ADVANCE	RVTRI(8,PF(LTMIN), _	Load passengers on C-141
		PF(LTMODE),PF(LTMAX))	
	LEAVE	PF(CHALK),2	Release C-141 for next
			increment
	TRANSFER	,DONE	Send to segment which
			determines if all
			increments have been
			loaded on aircraft
MOVE	TEST NE	PF(CGOTYPE),2,DONE	If rolling stock, don't
			need to release MHE
	GATHER	PF(NMBRLNKD)+1	Wait until all increments
			for this piece of MHE
			have been loaded

*	TEST E	PF(FIRST),1,DONE	If its first increment, fall through
*	ADVANCE	8,2	Time for MHE to be driven back to staging area
*	TEST E	PF(KTYPE),40,CHK25K	Test if its on a 40K-Loader
*	LEAVE	KLOAD40	Release the 40K-Loader
	LEAVE	DRIVER	Release the MHE driver
	TRANSFER	,DONE	Transfer to segment to wait on other increments
CHK25K	TEST E	PF(KTYPE),25,REL10K	Test if its on 25K-Loader
	LEAVE	KLOAD25	Release the 25K-Loader
	LEAVE	DRIVER	Release the MHE driver
	TRANSFER	,DONE	Transfer to segment to wait on other increments
REL10K	LEAVE	FL10K	Release the 10K-Forklift
	LEAVE	DRIVER	Release the MHE driver
DONE	GATHER	PF(NOINC)	Hold here until all increments for chalk have been loaded
*			
*	TEST NE	PF(INCNUMBR),1,REL141	If its not the first increment for chalk send through
*			
	TERMINATE	0	Destroy increment X-act
REL141	TEST E	PF(CGOTYPE),4,CGOLOAD	If passengers don't need to release load team
*			Release passenger monitor
	LEAVE	DRIVER	
	TRANSFER	,BLCKOUT	
CGOLOAD	LEAVE	LDTEAM	Release load team
BLCKOUT	ADVANCE	20,5	Time to get aircraft blocked out
*			
	LEAVE	ACFTC141	Release aircraft parking spot and proceed to chalk departure/terminal complete information output segment
*			
*			
*			
*			
*			
INFO	BPUTPIC	LINES=1,FILE=SYSPRINT,_ (PF(CHALK)),(PF(MSN)),_ (AC1),(PF(DEPTIME)-30)	Prints output information to LIS file
OChalk	***	Mission ***	Terminal Complete ****, Scheduled TC Time ****
*			
	TERMINATE	1	Decrease termination by one
*			
*			
*****			
*	C-5 Aircraft Loading Model Segment		*
*****			
*	THIS SEGMENT MUST BE COMPLETED IN ORDER TO MODEL THE FULL DEPLOYMENT		
*			
*****			



```

*           Run-Control Statements           *
*****
*
*           START      51                      Run model until the 51
*                                           airdrop chalks have
*                                           departed (WILL NEED TO
*                                           INCREASE TO TOTAL NUMBER
*                                           OF MISSIONS FOR FULL
*                                           SCALE MODEL USE)
*           END                      End model execution
*
* WHEN RUNNING FULL SCALE EXPERIMENTATION, CONTROL LOGIC WILL NEED TO
* BE ADDED TO GET THE DESIRED NUMBER OF REPLICATIONS

```

## Appendix E: "LDINFO" File

### MASTER CHALK INFORMATION FILE (SAVED UNDER A:LDINFO.TXT)

The 1st column contains the chalk number, the 2nd column contains the mission number, the 3rd column contains the number of increments on chalk, the 4th column contains the aircraft departure time (in absolute computer clock time), the 5th column contains the branch of service for mission (100=Air Force, 300=Army), and the 6th column contains the aircraft type for the chalk

\*\* These comments need to be deleted for actual model runs

\*\* For the sensitivity analysis experimentation this file was reduced to chawks 8 through 58 since they were the only airdrop cargo chawks

001	076	01	1145	100	141
002	077	08	1150	300	141
003	078	08	1180	300	141
004	074	36	1195	100	005
005	075	30	1200	100	005
006	079	06	1210	300	141
007	080	07	1240	300	141
008	051	01	1755	300	141
009	050	02	1765	300	141
010	049	02	1775	300	141
011	048	02	1785	300	141
012	047	04	1795	300	141
013	046	04	1805	300	141
014	045	02	1815	300	141
015	044	02	1825	300	141
016	043	02	1835	300	141
017	042	04	1845	300	141
018	041	04	1855	300	141
019	040	04	1865	300	141
020	039	04	1875	300	141
021	038	04	1885	300	141
022	037	04	1895	300	141
023	036	04	1905	300	141
024	035	04	1915	300	141
025	034	04	1925	300	141
026	033	04	1935	300	141
027	032	04	1945	300	141
028	031	04	1955	300	141
029	030	04	1965	300	141
030	029	04	1975	300	141
031	028	04	1985	300	141
032	027	03	1995	300	141

033 026 04 2005 300 141  
034 025 04 2015 300 141  
035 024 04 2025 300 141  
036 023 04 2035 300 141  
037 022 04 2045 300 141  
038 021 04 2055 300 141  
039 020 04 2065 300 141  
040 019 04 2075 300 141  
041 018 04 2085 300 141  
042 017 04 2095 300 141  
043 016 04 2105 300 141  
044 015 04 2115 300 141  
045 014 03 2125 300 141  
046 013 04 2135 300 141  
047 012 04 2145 300 141  
048 011 04 2155 300 141  
049 010 04 2165 300 141  
050 009 04 2175 300 141  
051 008 04 2185 300 141  
052 007 04 2195 300 141  
053 006 04 2205 300 141  
054 005 04 2215 300 141  
055 004 04 2225 300 141  
056 003 28 2235 300 141  
057 002 28 2245 300 141  
058 001 28 2255 300 141  
059 073 01 2965 300 141  
060 072 01 2965 300 141  
061 071 01 2965 300 141  
062 070 01 2965 300 141  
063 069 01 2965 300 141  
064 068 01 2965 300 141  
065 067 01 2965 300 141  
066 066 01 2965 300 141  
067 065 01 2965 300 141  
068 064 01 2965 300 141  
069 063 01 2965 300 141  
070 062 01 2965 300 141  
071 061 01 2965 300 141  
072 060 01 2965 300 141  
073 059 01 2965 300 141  
074 058 01 2965 300 141  
075 057 01 2965 300 141  
076 056 01 2965 300 141  
077 055 01 2965 300 141  
078 054 01 2965 300 141  
079 053 01 2965 300 141  
080 052 01 2965 300 141  
081 104 07 3105 300 141  
082 200 09 3110 300 141  
083 201 10 3115 300 141  
084 202 09 3120 300 141

085 203 09 3150 300 141  
086 100 15 3160 300 005  
087 102 15 3190 300 005  
088 103 15 3220 300 005  
089 105 06 3235 300 141  
090 204 09 3240 300 141  
091 205 05 3245 300 141  
092 206 05 3250 300 141  
093 106 07 3265 300 141  
094 107 07 3295 300 141  
095 207 05 3300 300 141  
096 208 05 3305 300 141  
097 108 06 3325 300 141  
098 209 05 3330 300 141  
099 109 07 3355 300 141  
100 210 05 3360 300 141  
101 110 07 3385 300 141  
102 211 06 3390 300 141  
103 212 06 3400 300 141  
104 213 06 3430 300 141  
105 101 10 3435 300 005  
106 111 07 3450 300 141  
107 214 10 3455 300 141  
108 215 02 3460 300 141  
109 112 06 3480 300 141  
110 216 06 3490 300 141  
111 113 06 3510 300 141  
112 217 11 3520 300 141  
113 218 09 3525 300 141  
114 114 07 3540 300 141  
115 115 09 3570 300 141  
116 219 11 3575 300 141  
117 220 11 3580 300 141  
118 221 11 3585 300 141  
119 222 09 3590 300 141  
120 116 09 3600 300 141  
121 117 09 3630 300 141  
122 223 11 3635 300 141  
123 224 11 3645 300 141  
124 400 15 3720 100 005  
125 500 19 3765 100 005  
126 501 18 3775 100 005  
127 403 07 3855 100 141  
128 406 11 3870 100 141  
129 300 08 4695 300 005  
130 401 33 4725 100 005  
131 402 21 4770 100 005  
132 404 20 4810 100 005  
133 405 22 5025 100 005

## Appendix F: "LDPLANS" File

### LOAD PLAN INFORMATION FILE (SAVED AS A:LDPLANS.TXT)

This trace file is used to assign increment type codes to X-acts coming out of the SPLIT block in the model. This file is arranged as follows:

The 1st column contains the increment number for that particular increment within the chalk, the 2nd column contains the increment type code (corresponds with the first column in PROCTYM.TXT matrix data file), and the 3rd column contains the chalk number (this column is not read by the computer, its there to aid in building and trouble shooting the file).

\*\* These comments need to be deleted before this trace file can be used to run the model.

\*\* For the sensitivity experimentation this file was reduced to chalks 8 through 58 since they were the only airdrop cargo loads

01	058	001
01	042	002
02	042	
03	016	
04	016	
05	016	
06	016	
07	022	
08	061	
01	042	003
02	042	
03	016	
04	016	
05	016	
06	016	
07	020	
08	061	
01	042	004
02	042	
03	042	
04	042	
05	042	
06	042	
07	042	
08	042	
09	042	
10	042	
11	042	

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005

28	069	
29	069	
30	059	
01	024	006
02	019	
03	019	
04	019	
05	019	
06	061	
01	016	007
02	016	
03	016	
04	016	
05	016	
06	016	
07	061	
01	001	008
01	001	009
02	002	
01	001	010
02	002	
01	001	011
02	002	
01	003	012
02	003	
03	003	
04	003	
01	003	013
02	003	
03	003	
04	003	
01	004	014
02	002	
01	005	015
02	002	
01	057	016
02	002	
01	003	017
02	003	
03	003	
04	006	
01	007	018
02	007	
03	008	
04	008	
01	007	019
02	007	
03	008	
04	008	
01	007	020
02	007	
03	008	

04 008	
01 007	021
02 007	
03 008	
04 008	
01 007	022
02 007	
03 008	
04 008	
01 003	023
02 003	
03 003	
04 003	
01 007	024
02 007	
03 008	
04 008	
01 007	025
02 007	
03 009	
04 009	
01 010	026
02 010	
03 010	
04 003	
01 010	027
02 010	
03 010	
04 003	
01 010	028
02 010	
03 010	
04 003	
01 010	029
02 010	
03 010	
04 003	
01 011	030
02 011	
03 011	
04 003	
01 003	031
02 003	
03 003	
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01 012	032
02 013	
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01 003	033
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01 003	034
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01 014	037
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01 014	040
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01 003	041
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01 003	043
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01 003	044
02 003	
03 003	
04 003	
01 012	045
02 013	
03 003	
01 003	046
02 003	
03 003	
04 003	
01 011	047

02 011	
03 011	
04 003	
01 010	048
02 010	
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04 003	
01 010	049
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04 003	
01 010	050
02 010	
03 010	
04 003	
01 010	051
02 010	
03 010	
04 003	
01 007	052
02 007	
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04 009	
01 007	053
02 007	
03 008	
04 008	
01 003	054
02 003	
03 003	
04 003	
01 007	055
02 007	
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04 008	
01 015	056
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01 058	061
01 058	062
01 058	063
01 058	064
01 058	065
01 058	066
01 058	067
01 058	068
01 058	069
01 058	070
01 058	071
01 058	072
01 058	073
01 058	074
01 058	075
01 058	076
01 058	077
01 058	078
01 058	079
01 058	080
01 016	081
02 016	
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04 016	
05 107	
06 108	
07 061	
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01 016	087
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05 108	

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01 024	095
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03 016	
04 016	
05 019	
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05 027	
01 018	101
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04 027	
05 027	
06 107	
07 061	
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02 016	
03 016	

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05 016	
06 107	
01 016	103
02 016	
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05 016	
06 016	
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02 016	
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05 016	
06 107	
07 061	
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01 016	109
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03 016	
04 016	
05 016	
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02 042	



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07 021	
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06 021	
07 021	

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09	021	
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03	042	
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07	042	
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05	042	
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04	070	
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07	071	
08	071	
09	073	
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12	074	
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03	077	
04	077	
05	075	
06	075	
07	074	
08	074	
09	074	
10	042	
11	042	
12	071	
13	078	

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16 080	
17 081	
18 081	
19 059	
01 042	126
02 042	
03 082	
04 082	
05 082	
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09 075	
10 084	
11 076	
12 081	
13 081	
14 071	
15 073	
16 085	
17 078	
18 059	
01 070	127
02 070	
03 070	
04 070	
05 078	
06 063	
07 061	
01 086	128
02 070	
03 042	
04 042	
05 042	
06 042	
07 042	
08 088	
09 089	
10 087	
11 062	
01 043	129
02 043	
03 043	
04 031	
05 031	
06 031	
07 031	
08 031	
01 087	130
02 087	

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## Appendix G: "PROCTYM" File

### DEPLOYMENT MODEL INCREMENT TYPE MATRIX FILE

The 1st column contains increment type code number, 2nd column contains increment weight, the 3rd column contains number of pallet positions occupied by increment, the 4th column contains minimum scale times, the 5th column contains maximum scale times, the 6th column contains mode scale times, the 7th column contains minimum loading times, the 8th column contains maximum loading times, the 9th column contains mode loading times, the 10th column contains cargo or load type (1=pallet, 2=rolling stock, 3=airdrop, and 4=passengers), the 11th column contains frustration probability, and the 12th column, which is not read by the computer, contains the increment type description (AD=airdrop, R/S=rolling stock, PLT=pallet, and F/L=floor load)

\* When running this file in the model, these comments need to be deleted

001	38500	3.9	032	053	045	010	025	017	3	000	M-551 Sheridan Tnk (AD)
002	04000	1.1	002	008	006	004	008	006	3	000	8' MASS (AD)
003	10500	2.4	006	031	011	003	024	009	3	000	M-998 GP HMMWV (AD)
004	38200	3.8	011	026	017	008	017	012	3	000	950-B Loader (AD)
005	37000	4.3	010	026	018	010	017	014	3	000	130-G Grader (AD)
006	06250	1.9	006	012	009	004	009	006	3	000	13-Wheel Roller (AD)
007	10500	2.4	006	022	012	003	024	009	3	000	M-1038 GPW HMMWV (AD)
008	09000	2.5	006	022	012	003	024	009	3	000	M-102 105MM How (AD)
009	06500	1.9	003	015	008	003	011	006	3	000	M-101 Trailer (AD)
010	10500	2.4	006	022	012	005	011	008	3	000	M-966 TOW HMMWV (AD)
011	10500	2.4	006	022	011	003	024	009	3	000	M-1025 Arm HMMWV (AD)
012	21060	3.7	006	012	010	006	017	011	3	000	M-35 2.5 Ton Truck (AD)
013	08080	1.9	006	022	012	005	011	008	3	000	M-105 1.25T Trlr (AD)
014	10500	3.0	006	022	012	005	011	008	3	000	M-996 Ambulance (AD)
015	01295	0.3	001	004	002	001	005	002	3	000	CDS Bundle (AD)
016	06000	2.1	003	015	008	005	015	010	2	005	M-998 GP HMMWV (R/S)
017	06000	1.9	003	015	008	005	015	010	2	005	M-105 1.25T Trlr (R/S)
018	08000	2.3	003	015	008	005	015	010	2	005	M-996 Ambulance (R/S)
019	08000	2.2	003	015	008	005	015	010	2	005	M-1038 GPW HMMWV (R/S)
020	07400	2.0	003	015	008	005	015	010	2	005	M-966 TOW HMMWV (R/S)
021	06000	1.0	002	012	006	001	010	005	1	007	Explosive 463L (PLT)
022	07000	2.1	003	015	008	005	015	010	2	005	M-1025 Arm HMMWV (R/S)
023	06000	2.2	003	015	008	005	015	010	2	005	M-1037 (R/S)
024	15000	3.0	005	025	012	007	025	014	2	007	M-35 2.5 Ton Truck (R/S)
025	35000	3.6	005	025	012	007	025	014	2	007	M-923 ROWPU (R/S)
026	50000	2.2	003	015	008	005	015	010	2	005	M-936 Wrecker (R/S)
027	04000	2.1	003	015	008	005	015	010	2	005	M-167 Vulcan (R/S)
028	35000	2.8	004	017	010	006	017	012	2	006	M-551 Sheridan Tnk (R/S)
029	08000	7.2	010	030	020	015	045	030	2	005	AH-1S Helicopter (R/S)
030	03000	2.4	007	025	018	010	038	022	2	005	OH-58 Helicopter (R/S)

031	14000	5.6	010	030	020	015	045	030	2	005	UH-60 Helicopter (R/S)
032	35000	3.8	005	025	012	007	025	014	2	007	130-G Grader (R/S)
033	35000	2.4	005	025	012	007	025	014	2	007	D-5B Bulldozer (R/S)
034	35000	3.4	005	025	012	007	025	014	2	007	950-B Loader (R/S)
035	02400	3.0	003	015	008	005	015	010	2	005	M-342 2.5Ton D-Trk (R/S)
036	29000	4.3	005	025	012	007	025	014	2	007	M-817 5Ton D-Truck (R/S)
037	00000	000	000	000	000	000	000	000	0	000	210CFM Air Comp (R/S)
038	00000	000	000	000	000	000	000	000	0	000	13-Wheel Roller (R/S)
039	00000	000	000	000	000	000	000	000	0	000	15T Tilt Trailer (R/S)
040	28000	3.0	005	025	012	007	025	014	2	007	6K-RT Forklift (R/S)
041	28000	3.1	005	025	012	007	025	014	2	007	10K-RT Forklift (R/S)
042	04500	1.0	002	012	006	001	010	005	1	007	463L Pallet (PLT)
043	20000	3.1	003	015	008	005	015	010	2	005	M-146 Shelter (R/S)
044	00000	000	000	000	000	000	000	000	0	000	M-147 Shelter (R/S)
045	00000	000	000	000	000	000	000	000	0	000	S250 Shelter (R/S)
046	00000	000	000	000	000	000	000	000	0	000	AGPU Power Supply (R/S)
047	00000	000	000	000	000	000	000	000	0	000	A-90 Shop Set (R/S)
048	00000	000	000	000	000	000	000	000	0	000	GRC-206 (R/S)
049	08800	2.5	003	015	008	005	015	010	2	005	M-1008 Truck (R/S)
050	06400	2.1	003	015	008	005	015	010	2	005	M-1009 Truck (R/S)
051	23700	3.2	005	025	012	007	025	014	2	007	10K-AT Forklift (R/S)
052	00000	000	000	000	000	000	000	000	0	000	13K-AT Forklift (R/S)
053	23000	2.5	005	025	012	007	025	014	2	006	10K-STD Forklift (R/S)
054	22540	3.7	010	035	028	020	055	035	2	004	25K-Loader (R/S)
055	24340	3.3	010	035	028	020	055	035	2	004	25K-TAC Loader (R/S)
056	00000	000	000	000	000	000	000	000	0	000	40K-Loader (R/S)
057	37100	3.5	011	020	015	007	014	010	3	000	D-5B Bulldozer (AD)
058	00000	0.0	000	000	000	055	072	063	4	005	100 Passengers
059	00000	0.0	000	000	000	045	065	055	4	004	75 Passengers
060	00000	0.0	000	000	000	030	045	038	4	003	50 Passengers
061	00000	0.0	000	000	000	020	030	026	4	002	25 Passengers
062	00000	0.0	000	000	000	008	016	012	4	001	10 Passengers
063	01500	1.2	003	015	007	003	010	006	2	005	NF-2 Light Cart (R/S)
064	01100	1.0	003	015	007	003	010	006	2	007	LOX Tank (R/S)
065	00320	0.6	003	015	007	003	010	006	2	005	Hydraulic Cart (R/S)
066	02100	0.9	003	015	007	003	010	006	2	004	MC-1A Compressor (R/S)
067	00360	1.0	001	004	002	002	003	004	1	001	A-10 Towbar (F/L)
068	02860	3.4	005	025	012	007	025	014	2	005	Tank Loader (R/S)
069	00200	0.2	001	004	002	001	003	002	1	006	Nesting Box (F/L)
070	10668	2.3	005	025	012	007	025	014	2	006	MHU-110 Trailer (R/S)
071	05920	1.9	003	015	008	005	015	010	2	005	Bobtail Jeep (R/S)
072	03355	1.8	003	015	008	005	015	010	2	007	Acft Engine Trlr (R/S)
073	11010	1.7	003	015	008	005	015	010	2	005	6K-STD Forklift (R/S)
074	06760	2.0	003	015	008	005	015	010	2	005	MHU-83 Bomb Lift (R/S)
075	02940	2.4	003	015	008	005	015	010	2	005	Ammo Loading Sys (R/S)
076	10800	1.9	005	025	012	007	025	014	2	006	MB-4 Tug (R/S)
077	02800	2.2	003	015	008	005	015	010	2	005	GFU-7/E (R/S)
078	00790	1.0	003	015	007	003	010	006	2	004	MC-2 (R/S)
079	00900	0.8	003	015	007	003	010	006	2	004	Heater Duct (R/S)
080	06760	2.0	003	015	008	005	015	010	2	005	MJ-1A Bomb Lift (R/S)
081	02100	1.4	003	015	007	003	010	006	2	004	TF-1 Light All (R/S)
082	04000	1.6	003	015	008	005	015	010	2	005	MHU-141 Trailer (R/S)



083	05600	1.1	003	015	008	005	015	010	2	005	-86 Generator (R/S)
084	05240	1.4	003	015	008	005	015	010	2	005	MJ-2A Mule (R/S)
085	06750	2.8	003	015	008	005	015	010	2	005	6 Pack Truck (R/S)
086	01740	1.1	003	015	008	005	015	010	2	005	Water Wash Cart (R/S)
087	00325	0.2	001	004	002	001	003	002	1	004	Fire Extinguisher (F/L)
088	05960	1.1	003	015	008	005	015	010	2	005	Generator Set 400 (R/S)
089	07335	1.9	003	015	008	005	015	010	2	005	Bobtail Tractor (R/S)
090	02150	2.1	002	008	005	003	011	008	2	003	B-1 Maint Stand (R/S)
091	01220	0.9	003	015	008	005	015	010	2	005	MA-1A Power Unit (R/S)
092	00400	1.0	001	004	002	002	003	004	1	001	C-130 Towbar (F/L)
093	04525	1.7	003	015	008	005	015	010	2	007	Dolly w/engine (R/S)
094	01350	0.5	002	008	005	003	011	008	1	004	Engine Change Cart (R/S)
095	03280	1.5	003	015	007	003	010	006	2	007	Nitro Trailer (R/S)
096	03480	1.5	003	015	008	005	015	010	2	005	-60 Generator (R/S)
097	02615	1.8	003	015	008	005	015	010	2	005	3000 Trailer (R/S)
098	00560	1.1	002	008	005	003	011	008	1	003	B-4 Maint Stand (R/S)
099	05810	1.7	003	015	008	005	015	010	2	005	12M Trailer EWS (R/S)
100	16060	3.0	005	018	010	003	011	005	1	004	3 Pallet Train (PLT)
101	00280	0.4	001	004	002	001	003	002	1	006	External Tester (F/L)
102	02880	1.2	002	008	005	003	011	008	2	003	Cabin Press Tstr (R/S)
103	00980	1.1	002	008	005	003	011	008	2	003	De-icing Cart (R/S)
104	02000	1.6	002	008	005	003	011	008	2	003	Fuel Tank FM (R/S)
105	02475	1.4	002	008	005	003	011	008	2	003	MC-7 Compressor (R/S)
106	00360	1.0	001	004	002	002	003	004	1	001	Nosewheel Towbar (F/L)
107	02800	1.7	003	015	008	005	015	010	2	005	M-101 Trailer (R/S)
108	03160	2.6	005	025	012	007	025	014	2	006	M-102 105MM How (R/S)

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### Vita

Captain John B. Prechtel was born on 31 January 1962 in Terre Haute, Indiana. He graduated from North Central High School in Farmersburg, Indiana in 1980. He then attended Indiana State University, graduating in May 1985 with a Bachelor of Science degree in Manufacturing Technology. In June 1987, he received his commission. He was then assigned to the Directorate of Distribution at McClellan AFB, California as the Assistant Air Terminal Manager. In March 1989, he was transferred to the 6th Aerial Port Squadron at Howard AB, Panama, where he served as Aerial Port Duty Officer. He was put in charge of the Passenger Terminal during Operation JUST CAUSE in December 1989 and he helped coordinate the redeployment of U.S. forces after the invasion. In June 1990, he was reassigned to the 3rd Mobile Aerial Port Squadron at Pope AFB, North Carolina. In early August 1990, he deployed with the squadron to Southwest Asia in support of Operation DESERT SHIELD. At the deployed location Captain Prechtel served as Duty Officer and Operations Officer. After 7 1/2 months in the Arabian Peninsula, he returned to Pope as the OIC of Plans and Mobility. He then attended Squadron Officer's School enroute to entering the Air Force Institute of Technology in May of 1992.

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### Vita

Captain Mark S. Wingreen was born on 23 June 1959 in Racine, Wisconsin. He graduated from Burlington High School in Burlington, Wisconsin in 1977 and attended the University of Wisconsin at Whitewater, graduating cum laude with a Baccalaureate degree (B.S.) in Mathematics in May of 1985. In June 1987, he received an Air Force commission and was subsequently assigned to the 831st Transportation Squadron at George Air Force Base, California. First, as the Vehicle Operations Officer, he was responsible for 45 military and civilian personnel and the management of a vehicle fleet valued in excess of \$10 million. Next, he served as OIC, Plans, Programs, and Mobility before reassignment to the 316th Aerial Port Squadron at Yokota Air Base, Japan in July 1989. There, he served briefly as an Air Terminal Operations Center Duty Officer before becoming the OIC of the largest Passenger Service operation in the Pacific theater. In January 1991, Captain Wingreen became Chief of Plans, Resources, and Mobility, and was also chosen by the wing commander to augment the 374th Tactical Airlift Wing as his executive officer. For the next six months, Captain Wingreen fulfilled the duties of both positions. He entered the Air Force Institute of Technology in May of 1992.

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# REPORT DOCUMENTATION PAGE

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